APPLIED MECHANICS Reviews

A C[illegible] WORLD LITERATURE IN APPLIED MECHANICS
[illegible] ENGINEERING SCIENCE

REVS. 1537-[illegible] VOL. 8, NO. 6 JUNE 1955

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Published Monthly by THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS at Easton, Pa., and edited by Midwest Research Institute with the co-operation of Linda Hall Library

APPLIED MECHANICS *Reviews*

Editorial Office: **APPLIED MECHANICS REVIEWS, Midwest Research Institute, 425 Volker Boulevard, Kansas City 10, Mo., U.S.A.**
Subscription and Production Office: **The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., U.S.A.**

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APPLIED MECHANICS REVIEWS, June 1955, Vol. 8, No. 6. Published Monthly by The American Society of Mechanical Engineers at 20th and Northampton Streets, Easton, Pa., U. S. A. The editorial office is located at the Midwest Research Institute, Kansas City 10, Mo., U. S. A. Headquarters of ASME, 29 West 39th St., New York 18, N. Y., U. S. A. Cable address: "Dynamic," New York. Price $1.50 per copy, $12.50 a year; to members of ASME and co-operating societies $0.75 per copy, $9 a year. Add $0.50 for postage to all countries outside the U. S., Canada, and Pan-American Union. Changes of address must be received at Society headquarters seven weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Laws: The Society shall not be responsible for statements or opinions advanced in papers or printed in its publications (B13, Par. 4). . . . Entered as second-class matter, January 11, 1948, at the Post Office at Easton, Pa., under the Act of March 3, 1897.

APPLIED MECHANICS REVIEWS

VOL. 8, NO. 6 **MARTIN GOLAND** *Editor* JUNE 1955

AERODYNAMICS

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Up to now, our failure to understand the mechanism of turbulent fluid motion has prevented aerodynamics from assuming the status of a logically unified science. This will soon be remedied as a consequence of recent advances. Aerodynamics will then be even more helpful than it is now. It can be expected to contribute at an increased rate to major technological advances. The outlook for aerodynamics looks brighter, therefore, right now than it ever did before.

I

Aerodynamics deals with the motion of fluids along conduits, past obstacles, and adjacent to vehicles. It overlaps hydrodynamics, hydraulics, and, to a lesser extent, acoustics. Studies in these branches of applied science date many years back. Newton, for example, published his ideas on flow resistance. The textbooks on classical hydrodynamics abound with references to Lagrange, Euler, and D. Bernoulli. Shock waves were photographed in 1887 and their theory was then well understood. The fundamental paper of Reynolds on viscous pipe flow is as old as the first shock-wave photographs. The motion of fluids has been intensely studied, and the physical relations governing these motions were well understood and mathematically formulated when the nineteenth century came to its close.

Thus, when the present century began, all was well prepared for building up a large collection of aerodynamical data and for developing a large body of theory for understanding these data. It is hardly necessary to tell the readers of these Reviews that this collecting, and this analysis of what was measured, have since been carried out on an unprecedented scale. One single modern aerodynamic test installation requires an investment sufficient to start a good-sized domestic industry. The theoretical research is commensurate in volume with the experimental research, and contains a creditable percentage of valuable papers. People who wish to become proficient in this department of knowledge must study many years and make aerodynamics their special profession.

All this may lead the reader to conclude that during the first half of this century aerodynamics has attained the status of a science. This is not, however, the case. Aerodynamics is not yet a science. An important ingredient is still missing as this is being written and has still to be supplied before aerodynamics will mature into a science. Strange to say, this large accumulation of data, methods, and theories is still logically incomplete and incoherent by the standards of other systems of technical learning. Fortunately, there are now strong indications that this will soon be changed. The shaping of aerodynamics into a logically complete and consistent science is just around the corner. New pregnant thoughts are just now coming to light to be incorporated into the body of the fundamental aerodynamic principles. The conversion into a firmly coherent science will then take place by fast steps.

The logical incompleteness of aerodynamics has its origin in the part played by the walls of the conduits or of the vehicle giving rise to the motion of the fluid. Naturally, what happens anywhere is ultimately traceable back to the action of such walls. But within the regions adjacent to the walls, fluids often execute a so-called turbulent motion. The only important exceptions are the lubricants filling the narrow space between a bearing and the journals supported by the bearing. It is significant in this connection that the theory of lubrication is not usually considered a branch of aerodynamics. It is free of the stigma of logical incompleteness. With most aerodynamic problems, the occurrence of turbulent motion is either a fact or a distinct possibility. There are then regions through which the fluid moves in an unsteady, broken-up, irregular, and decidedly random fashion. The fine details of this turbulent motion are so involved that it is never practical nor desirable to describe them all. The scientist, as well as the engineer, confines his attention to relevant statistical averages pertaining to the motion. The principle of sufficient reason, appearing here as causation, is, of course, not suspended. But it appears in a form which was not encountered before in classical science studies. The classical and simple equations of fluid motion govern each fragmentary flow detail by itself, notwithstanding the randomness of what happens. But the same equations do not immediately connect the boundary conditions with the statistical average of the pertinent quantities describing the turbulent fluid traffic as a whole. The turn of the century did not find us prepared to cope with such a situation. It required half a century longer to get the investigators into the right state of mind. In retrospect, this is hard to believe, but it is a fact.

This writer by no means stands alone in harboring such an opinion. The logical incoherence of aerodynamics is not the private fanciful imagination of a single person. On the contrary, this absence of understanding finds ready and frequent expression throughout the literature and is often complained

about in technical and scientific meetings. Toward the beginning of the period which we are now discussing, in 1913, the most outstanding worker in modern aerodynamics, Ludwig Prandtl, wrote as follows in his article in the "Handwoerterbuch der Naturwissenschaften": "Die Ursachen der Turbulenz sind trotz grosser Anstrengungen der Theoretiker bisher noch nicht aufgeklaert." (The cause of turbulence is not yet clarified notwithstanding the great efforts of the theoretical investigators.) Forty years later, quite recently, and toward the end of the period, the style of lamentation has hardly changed. G. K. Batchelor states in his recent book on homogeneous turbulence as follows: "These are complicated mechanical effects and we have not yet obtained a proper understanding of them." Batchelor also complains about an alleged "temporary dearth of new ideas," but there he was mistaken. As he wrote that, the new ideas were already well under way.

The logical incompleteness we are now discussing must not be confused with any possible inadequacy of mathematical methods relating to aerodynamic problems. Even if a problem is fully and completely understood, it may still be impractical to obtain numerical information. Only a few simple cases may be amenable to precise mathematical solution, and often not even that. Numerical methods may be excessively laborious and inexact, even in this age of mammoth electronic computing machines. That, however, would not constitute a shortcoming of aerodynamics, but a shortcoming of mathematics. We should not feel too badly about that. Such difficulties are inherent in mathematical work. We must wonder every time we see mathematics perform a logical miracle; we must not wonder when it cannot do everything. The principal use and aim of mathematics are, after all, not the production of numerical information. Mathematics' most noble function is giving aid in qualitative understanding of problems. Once such understanding has been achieved, the investigator has almost won his battle. He is then well entrenched and stands on solid ground. He is now much less dependent on mathematics and can bring to bear, in addition, all of his natural mental resources, particularly his intuitive faculty and his artistic and engineering feeling and judgment.

For the scientist and the engineer alike, mathematics constitutes chiefly a state of mind, a habit of healthy thinking. It is only secondly a set of rules on how to manipulate mathematical symbols and how to grind out numerical results. Prandtl and Batchelor must have had this in mind when they made the aforesaid statements.

They complain about the absence of understanding; they do not complain about obstacles to computation. Since they do do not understand, they cannot look through the sequence of mechanical happenings. They are painfully aware of this and feel that something immensely important is missing.

Pity the aerodynamicist. For the important and, indeed, essential aspects of his problems he is still traveling in such relative darkness. He is often expected to look through things which are still not transparent. He has no universally reliable posts to guide his thinking. True, he has a vast library of facts at his disposal and a large stock of information in his memory. It is fortunate he has, for otherwise what else would he fall back on? But a large stock of individual facts would be less necessary if supported by a well-organized science.

Fortunately, all this will now soon begin to improve.

II

Aerodynamics is just now maturing into a true, complete science. The new arguments, thoughts, and conclusions are interesting by themselves. They also teach appreciation for analogous technical advances in other fields. The foundations of older sciences are too often taken for granted, insufficiently studied if studied at all, uncritically learned, and dogmatically accepted. That is a poor way to derive fullest benefit from them. The understanding and appreciation of new thoughts are vitally important and cannot be obtained without looking back to the efforts preceding them. It is well worth while to look into the history of the theoretical efforts undertaken over a period of fifty years, aimed at understanding turbulence. The need for such understanding was clearly and impressively stated from the beginning. In discussing these things, it is far from the author's intention to belittle in any way these efforts, or the men who undertook them. Nothing in this article must be so misunderstood. The discussion is just to show how difficult fundamental steps are before the question is answered, much more difficult than they appear to be after the answer has been found.

We wish here to discuss only the purely theoretical approach to turbulence. Experimental research, save when following up and checking theory, does not lead to understanding. Theoretical turbulence research turned first to the simplest cases, the parallel channel flow. In 1908, A. Sommerfeld initiated a mathematical method of examining such flows, one that is still active today. Strange to say, Sommerfeld conceived no need to understand, or even consider, turbulent fluid motion as such. He shied away from turbulence and confined himself to studying laminar (nonturbulent) flow along pipes and the like. He raised the question of at what Reynolds number such laminar flow becomes unstable, in the sense that the strictly parallel flow is then no longer observed and a more complicated but still laminar flow is assumed by the fluid. Without going deeper into this question, Sommerfeld assumed tacitly, first, that there always exists such a critical Reynolds number and second, that the occurrence of such a critical Reynolds number necessarily leads to turbulence, so that the computed instability of the laminar flow is a necessary and sufficient condition for the establishment of turbulent motion. To this author's best knowledge, this assumption has never been critically analyzed in any paper, from 1908 to this day. It was beyond the initiative or did not occur to Sommerfeld to do so, and all his successors since 1908 considered it proper and convenient to rely on Sommerfeld and on each other, regarding this question.

Sommerfeld also taught the second step. The equation to be solved turned out to be nonlinear and untractable. Sommerfeld therefore linearized the equation; he crossed out higher powers of the dependent variables on the assumption that, with a very weak disturbance, the deleted terms would be much smaller than the linear terms. This second step was likewise uncritically adopted by his followers and has never been critically examined. It is, however, not always legitimate to linearize nonlinear equations by crossing out higher terms. This is only justified in specific instances. In the present case it has to be ascertained whether the simplification is in harmony with the aim of the investigation. It may well be that the conclusion derived from the linearized equation contradicts the correct and unmutilated equation.

Even the linearized equation proved very difficult to solve. An enormous amount of purely mathematical labor has gone into this equation for obtaining various solutions. The principal case was the simplest flow conceivable. That is, the so-called Couette flow of constant pressure, carried out between a pair of parallel channel walls, one wall moving in its own plane relative to the other. That is the only case that can be solved analytically; at least, it looked as if it could. The problem was first solved by L. Hopf in 1914. His result was highly disappointing. Hopf found no critical Reynolds number for the Couette flow, but he established that the equation indicates stability of the laminar flow for every Couette flow regardless of the magnitude of its Reynolds number. This mathematical result is not cor-

roborated by any experimental research, and it appears unacceptable to all physicists and aerodynamicists on the strength of common sense. This disappointing result quite at the beginning did not, however, make the mathematicians lose faith in the procedure. Other flows did not disappoint in this fashion. Instead, doubts were cast on Hopf's work. Only a few years ago a noted mathematician was still engaged in a mathematical investigation directed to prove that Hopf was mistaken. Hopf replaced certain Bessel functions by their asymptotic expressions. This step was suspected to falsify the result. It seems that the outcome of this belated investigation has never been published. It must therefore be assumed that the result of Hopf's original computation still stands. The linearized equation indicates stability of the Couette flow for all Reynolds numbers, as far as it indicates anything at all.

It is only recently that criticism of Sommerfeld's approach has become widespread. Research projects based on Sommerfeld's method are still under way.

Later we shall discuss Reynolds' earlier work. Sommerfeld's is the only accepted theoretical method leading to a mathematical procedure. Other contributors furnished only comment or else did not steer free of experiment.

The so-called statistical theory of turbulence can hardly be considered a theoretical approach. It is experimental research analyzed by means of high-powered methods from the mathematical theory of statistics. No serious attempts are made to understand turbulent fluid motion on purely rational grounds. Some sponsors hope apparently to arrive at such understanding by way of a miracle, as a reward, perhaps, for the intricacy of the mathematics used. According to Batchelor, previously cited, this miracle has not happened so far. Batchelor should know. He is one of the principal proponents of that mode of research.

III

It is hard to understand in retrospect how anybody could expect to understand turbulent fluid motion by turning his eyes away from it, as if turbulent fluid motion were an object of horror and loathing. The difficulties in the way to understanding melt away as soon as we bring up enough faith and determination to look squarely and searchingly right at the phenomenon itself which we wish to understand. We must steadfastly keep our eyes wide open and directed at the novel and puzzling aspects—randomness and fragmentation. We must not look back for one minute to the comfortable and accustomed domain of analytic fields and continuous, smooth stream functions. Rather, the novel features must be expected to themselves furnish the explanation we are looking for. O. Reynolds believed in such a way of inquiry and undertook an investigation in that direction as early as 1894. He failed, however, to gain applause and this may have discouraged others from following him.

We will be successful if we concentrate on our aim and call clearly to mind what it is that keeps us from being in the comfortable state of understanding. What particular information is lacking that would get us there? The answer is simple. We need a list or enumeration of the dominating mechanical effects governing the turbulent flow. We have to establish such a list, and we have to attain clarity regarding the physical relations between the various effects and the variable conditions of the flow. Since we are studying statistical averages of large pluralities of fragmentary flow motions, the effects must also constitute such averages. The effects must themselves be averages of random effects. Completeness and high precision of the arguments are not necessary at the beginning. The simplest logical system will be the best, provided it is adequate to describe the relevant happenings in a logically coherent fashion.

It did not prove unusually difficult to arrive at such a system of effects and relations once this approach was firmly decided on. Straightforward mathematics was sufficient. This paper is not the place to describe this rugged and common sense theory. A few remarks about the outcome are not, however, out of order.

Turbulent fluid motion is governed in combination by the equilibrium of momentum transfer and by the balance of turbulence energy. Both depend on the intensity and on other aspects of the turbulence. The momentum transfer determines the change or preservation of the velocity profile of the more or less parallel flow. The turbulence-energy concentration is changed or preserved by the combination of four physically separate effects. Dissipation diminishes the energy continually. If there were nothing else, turbulence would indeed be mysterious. Augmentation replenishes the energy; this is an effect of turbulence itself in co-operation with the shear or slope of the velocity profile. Convection and diffusion finally transport energy from place to place, and round out the picture. In some respects the velocity profile, its change or preservation, stand in the center of interest. Augmentation by itself cannot maintain turbulence unless it modifies the profile suitably for supplying an adequate amount of energy from the boundaries into the flow.

The theory of 1908 made no appeal to randomness, none to a change of the profile, and none to the energy balance. It was not preceded by understanding, nor did it lead to it. If the attempt had been shrewder and had given correct results, it still would have failed in the most noble functions of a theory, which is to dispense understanding and to impart conviction.

IV

Aerodynamics is most positively an applied or engineering science; it is not a basic science at all. The laws of mechanics and the properties of fluids were established long ago by the physicists and there is no doubt about the adequacy of these laws for aerodynamic studies. The motion of the fluid follows immediately and necessarily from these laws. But the problem of how to arrive at these motions, how to understand them, and how to predict them is not solved once the basic laws have been found. That is an entirely separate problem and one beset with great obstacles. The history of turbulence research during the past decades shows this conclusively. It requires genuine mental effort on the highest level to fill the gap between the pronouncements of the physicists and the needs of the engineers. These applied studies require no less willingness to resolve every doubt, to familiarize oneself with every aspect, to follow up the significance of every conclusion, than is required for basic studies. A strong sense of reality must be cultivated, and all thinking must be substantial and not merely formal. Mathematics has to be used sparingly and efficiently, and always in company with natural thinking. The more this is done, the more will the particular science prosper.

An important step in the building of the logical foundation of aerodynamics has just been taken. This fully entitles us to healthy optimism regarding its further growth. The incompleteness of understanding did not prevent aerodynamics from rendering good service in the past. The impact of aerodynamics on technical development was enormous. Without systematic research and study, modern aeronautical equipment would not have come into being. Without continued progress in aerodynamics, any great country loses its military strength.

Crowning now all that precious knowledge with new and better understanding will naturally increase its usefulness. Turbulence, as well as its absence, will become more predictable. Definite standards and bounds of performance are no longer out of reach. Missiles will fly better and farther.

Books Received for Review

CHESTNUT, H., AND MAYER, R. W., Servomechanisms and regulating system design, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1955, xiii + 384 pp. $8.50.

COLLATZ, L., Numerische Behandlung von Differentialgleichungen, 2nd rev. ed. (Grundlehren der mathematischen Wissenschaften, Bd. 60), Berlin, Springer-Verlag, 1955, xv + 526 pp., 118 figs. DM 56.

DAVIS, H. E., TROXELL, G. E., AND WISKOCIL, C. T., The testing and inspection of engineering materials, new 2nd ed., New York, Toronto, London, McGraw-Hill Book Co., Inc., 1955, xv + 431 pp. $6.50.

GOLDMAN, O. G., Water hammer—its cause, magnitude, prevention, Columbia, Conn., Columbia Graphs, 1953, xii + 116 pp. $5.

GREEN, A. E., AND ZERNA, W., Theoretical elasticity, New York, London, Oxford Univ. Press, 1954, xiii + 442 pp. $8.

GROVER, H. J., GORDON, S. A., AND JACKSON, L. R., Fatigue of metals and structures, Bureau of Aeronautics, Dept. of the Navy; Superintendent of Documents, U. S. Govt. Ptg. Office, Washington, D. C., 1954, x + 394 pp. $2.50.

HAINES, J. E., Automatic control of heating and air conditioning, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1953, viii + 370 pp. $6.75.

KASPER, L., Cams—design and layout, New York, Chemical Publishing Co., Inc., 1954, 101 pp. $3.50.

MAZET, R., Mécanique vibratoire, Paris & Liège, Libraire Polytechnique Ch. Béranger, 1955, xix + 280 pp.

MÉTRAL, A. R., edited by, La machine-outil. T. III. Usinage par outils en rotation, Paris, Dunod, 1954, 432 pp.

MÉTRAL, A. R., edited by, La machine-outil. T. VI. Usinage par abrasion, Paris, Dunod, 1954, 168 pp.

PERRY, C. C., AND LISSNER, H. R., The strain gage primer, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1955, xi + 281 pp. $6.

ROSE, H. E., The measurement of particle size in very fine powders, New York, Chemical Publishing Co., Inc., 1954, 127 pp. $2.75.

WARD, G. N., Linearized theory of steady high-speed flow, New York, Cambridge University Press (Cambridge Monographs on Mechanics and Applied Mathematics), 1955, xv + 243 pp. $6.

Theoretical and Experimental Methods

(See also Revs. 1564, 1566, 1569, 1577, 1586, 1597, 1601, 1667, 1682, 1707, 1710, 1721, 1722, 1736, 1742, 1815, 1827, 1859, 1863, 1867)

1537. Soroka, W. W., Analog methods in computation and simulation, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1954, xii + 390 pp. $7.50.

Book consists principally of a synthesis of articles over a 25-year range, with references to original work beyond articles quoted. Graduate appreciation is required in relevant field, and reference to quoted works is essential for practical detail. First two chapters develop mechanical and electrical elements for subsequent combination in chaps. 3 and 4; e.g., in chap. 2, inverted circuit variable-mu tube for output as antilog of input. Useful, realistic warnings of technical limitations are given at end of chapters.

Chap. 5 starts with good 7-page history, fully referenced as always, of mechanical differential analyzer; 24 pages follow on different approaches, then page of examples of applications with pointers, such as smoothing of integration better than peaking of differentiation, as in backlash of gears. Chap. 6, electronic analog computers, deals solely with differential analyzers and not with digital computers, doubtless due to space limitations, which is given as reason for only occasional reference to equation transformation to efficient forms for application in analog and simulation methods.

Chap. 7 is concerned with dynamical analogies and mentions use to represent color vision and explain color blindness; quotes mechanical analogy for muscle in control systems involving human element. Chap. 8, typical of alternatives here presented, is an analogy developed through the finite difference approach to obtain a circuit requiring transformers but not the negative springs of the lumped model, to represent beams in equivalent lumped systems, developed by means of influence numbers, in a dynamical analogy suitable for transient analysis. After chap. 9, on membrane and conducting sheet analogies, an excellent author and subject index is given.

Reviewer regrets the absence of some statistical analogies which could well have gone as far back as Karl Pearson's generalized binomial machine [*Phil. Trans. roy. Soc. Lond.* (*A*) **186**, p. 343, 1895]. An extensive sampling check on detail only revealed that Eq. (2.6) introduces *e*3 and *R*3, which are neither in relevant Fig. 2.1(c) nor context of section 2.1. Small inconsistency of presentation; e.g., chap. 2, adjective "iterative," which must be known in technical meaning to readers capable of following context, would have saved 34 words! And, in chap. 7, first dozen pages could be condensed to a couple at general level.

T. U. Matthew, England

1538. Erdélyi, A., Magnus, W., Oberhettinger, F., Tricomi F. G., Higher transcendental functions. Vol. III (**Bateman Manuscript Project**), New York, McGraw-Hill Book Co., Inc., 1955, xvii + 292 pp. $6.50.

This is the final volume of a set of five prepared by the staff of the Bateman Manuscript Project. For vols. I and II of "Higher transcendental functions" (HTF), see AMR **7**, Revs. 1365, 1366. For vols. I and II of "Tables of integral transforms," see AMR **7**, Rev. 2056 and AMR **8**, Rev. 900. System of references is the same as in previous volumes. There are a subject index and an index of notations. For the HTF series, chaps. 1 to 6 compose vol. I; chaps. 7 to 13 are in vol. II.

Present volume is composed of chaps. 14 to 19. Chaps. 14 and 17 deal with automorphic functions and functions of number theory, respectively. They are admittedly experimental for a work of this kind, but authors hope they will prove sufficiently useful to justify their inclusion. Chapters are not a full coverage, but are designed to give basic definitions and concepts and to provide sufficient references for additional information. Lamé functions are taken up in chap. 15. Chief attention is devoted to more recent theories of Lamé and Lamé-Wangerin functions. Chap. 16 is concerned with Mathieu functions, spheroidal and ellipsoidal wave functions. Treatment of Mathieu functions leans heavily on the volume by McLachlan ["Theory and application of Mathieu functions," Oxford, 1947] which contains many applications and a bibliography. Material on spheroidal wave functions follows recent papers of Meixner. In connection with this chapter, there is recent work of Meixner and Schäfke [see AMR **8**, Rev. 1256]. Chap. 18 considers some miscellaneous functions such as Mittag-Leffler's $E_\alpha(z)$ and related functions. Chap. 19 is concerned with generating functions. First part contains a general survey with applications. Second part is a list of formulas.

In conclusion, set is of immense value to pure and applied workers. The work is unparalleled and fills an urgent need. Editor and staff are to be congratulated for accomplishment of a most difficult task. Volumes manifest scholarly spirit and profundity of the late Harry Bateman in whose memory they are inscribed.

Y. L. Luke, USA

1539. **Abramowitz, M., On the practical evaluation of integrals,** *J. Soc. indust. appl. Math.* **2**, 1, 20–35, Mar. 1954.

This is a valuable expository paper. Nine examples are fully treated to illustrate possible means of analysis. An excellent summary of suggested techniques for investigating an integral is presented.

Y. L. Luke, USA

1540. **Serbin, H., Note—Numerical quadrature of some improper integrals,** *Quart. appl. Math.* **12**, 2, 188–194, July 1954.

1541. **Olver, F. W. J., The asymptotic solution of linear differential equations of the second order for large values of a parameter,** *Phil. Trans. roy. Soc. Lond.* (*A*) **247**, 930, 307–327, Dec. 1954.

Paper studies asymptotic expansions of solutions of differential equation $d^2w/dz^2 + \{up(z) + q(z)\} = 0$ for large values of parameter u. This form is not unduly restrictive and is adopted, since many important equations are either in this form or may be readily transformed into it; e.g., the equations of Bessel, Weber, and Legendre. If D is the domain of definition, a transition point is one such that $p(z)$ vanishes, or $p(z)$ or $q(z)$ has a singularity in D. Three cases are studied. They occur when in D the differential equation has (1) no transition points, (2) one transition point, a simple zero of $p(z)$, (3) one transition point, a double pole of $p(z)$. The series solution is of the form

$$w(z) = P(z)\left(1 + \sum_{s=1}^{\infty} A_s(z)/u^s\right) + (P'(z)/u) \sum_{s=0}^{\infty} B_s(z)/u^s$$

where $P(z)$ is an exponential function for cases (1) and (3) and is Airy's function for case (2). The coefficients $A_s(z)$ and $B_s(z)$ are given by recurrence relations. Important practical point is that general tabulation of $w(z)$, which is a function of two variables z and u, is in the main reduced to the preparation of a few single entry tables. Further, the results are uniform with respect to the complex variable z.

This is an important paper and represents an advance over that of prior workers in this field.

Y. L. Luke, USA

1542. **Guest, J., The solution of linear simultaneous equations by matrix iteration,** *Aero. Res. Lab. Melbourne, Austral. Rep.* SM.225, 25 pp., 1 table, Sept. 1954.

The algorithm proposed here is similar to that of Stiefel, in being adapted to simple programming on an automatic computer, and terminating in n steps, n being the order of the matrix. Both the matrix of coefficients and its transpose are operated on simultaneously, successive vector solutions being orthogonalized with that of the transpose. In the example given, the convergence is much better than that obtained with Stiefel's method. It is claimed to be better than Crout's method for $n > 10$.

G. W. King, USA

1543. **Erdmann, S. F., and Oswatitsch, K., A quick linear method of characteristics for axial and oblique supersonic flow past bodies of revolution with concentric rings** (in German), *Z. Flugwiss*, **2**, 8, 201–215, Aug. 1954.

A new method of characteristics is given for the linearized equation of supersonic flow. The method is applicable to the case of oblique flow past concentric rings around slim pointed bodies of revolution, and reduces to the Sauer-Heinz method when the flow is incident along the axis of symmetry. When concentric rings are absent, the method is shown to correspond to the singularity technique outlined by Tsien.

Expressions for the pressure coefficients are obtained in terms of the velocities in the field, and the results are applied to a flow problem introduced by W. Haack [AMR **5**, Rev. 793].

A. R. Mitchell, Scotland

1544. **Geiringer, Hilda, Remarks on the theory of characteristics** (in German), *Öst. Ing.-Arch.* **8**, 2/3, 107–109, 1954.

For two planar partial differential equations of first order, directional condition and compatibility condition are given in a symmetric form exhibiting the existing identities.

From author's summary

1545. **Lozinskiĭ, S. M., On approximate solution of systems of ordinary differential equations** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **97**, 29–32, 1954.

Previous papers [title source, **92**, 225–228; **93**, 621–624, 1953; **94**, 17–19, 1954] gave conditions under which a solution of a system of ordinary differential equations would exist on a specified interval, and provided estimates of the deviation of an approximate solution from the true solution. The present theorems are an attempt to restate the results in a form that can be more readily applied.

A. S. Householder, USA

1546. **Mel'nik, S. I., Oscillating functions and their application to approximate solution of integral equations** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **95**, 705–708, 1954.

A function $f(p)$ which, together with its square, is summable over a region ω, is said to be an oscillating function in case ω can be subdivided into nonoverlapping regions ω_i such that ${}_{\omega_i}\int f(p) d\omega_p = 0$ for every i. Now given an integral equation $u(p) - f(p) - {}_{\omega}\int k(p, q)u(q)d\omega_q = 0$, one can undertake to approximate the solution u by a linear combination of n orthogonal functions θ_i: $u_n = \Sigma a_i\theta_i(p)$. When u_n replaces u, the left member of the integral equation is a function $\psi_n(p, a_1, \ldots, a_n)$ and there are various conditions one can apply to ψ_n so as to determine the a_i. In this paper is considered in particular the requirement that the ψ_n be an oscillating function. A theorem and a corollary bound the error of an approximate solution, but the conclusions are obscured by evident misprints.

A. S. Householder, USA

1547. **Varoli, G., Some observations on an iteration method for the approximate solution of equations** (in Italian), *Period. Mat.* (4) **32**, 70–76, 1954.

Given the existence of a real root α of $x = \varphi(x)$, known to be unique and simple in the interval (a, b), the problem considered concerns the convergence to α of a real sequence $\alpha_1, \alpha_2, \ldots$, where $\alpha_{t+1} = \varphi(\alpha_t)$. Necessary and sufficient for the existence of an $\alpha_1 \neq \alpha$, for which the sequence converges to α, is the existence of an interval (a', b') containing α within which $|\varphi'(x)| < 1$, but α_1 may or may not need to lie on this interval. The author considers graphically a number of cases that may arise.

A. S. Householder, USA

1548. **Vietoris, L., Truncation error of an approximative solution obtained by the Adams interpolation method for the equation $y' = f(x,y)$** (in German), *Öst. Akad. Wiss. math.-nat. Kl. S.B.* IIa, **162**, 5/7, 157–167, 1953.

The method of Adams for the differential equation $y' = f(x, y)$ with $y(x_0) = y_0$ refers to pivotal points $x_i = x_0 + ih$, $i = 0, 1, \ldots$. It leads to an approximate value η_{n+1} for $y(x_{n+1})$ by extrapolation from the values $\eta_n, \eta_{n-1}, \ldots, \eta_{n-r}$. It is assumed that $\eta_0, \eta_1, \ldots,$

η_r are given. The extrapolation can be described by means of a polynomial $\eta_{n+1}(x)$, such that $\eta_{n+1}(x_{n+1}) = \eta_{n+1}$; $\eta_{n+1}(x)$ has no higher degree than $r + 1$ and is defined by $\eta_{n+1}(x_n) = \eta_n$; $\eta'_{n+1}(x_i) = f(x_i, \eta_i)$ for $i = n, n - 1, \ldots, n - r$. Estimates for the error of the method in the pivotal points have been given by various authors. The subject of this paper is to derive estimates for $q_{n+1}(x) = f(x, \eta_{n+1}(x)) - \eta'_{n+1}(x)$ in the whole interval $x_n \leqq x \leqq x_{n+1}$. The author admits that the defining relations for the $\eta_{n+1}(x)$ are not exactly satisfied due to errors of computation. Instead he assumes that the relations

$$\eta_{n+1}(x_n) = \eta_n(x_n), \qquad \eta'_{n+1}(x_i) = \eta_n'(x_i)$$

for $i = n, n - 1, \ldots, n - r + 1$ hold and that inequalities $|\eta_n'(x_n) - f(x_n,\eta_n)| < \rho$, $|\eta'_{n+1}(x_{n+1}) - \eta_n'(x_{n+1})| < \sigma$ exist with ρ and σ covering the whole range of integration. (The reviewer does not quite understand these assumptions. He feels that the σ-inequality should read with x_n instead of x_{n+1} and that the subscript in the equalities for $\eta_n'(x_i)$ should run from $i = n - 1$ to $i = n - r$.) Under suitable assumptions on the derivatives of $f(x, y)$, the results are some estimates for q_{n+1}, a typical one of them being

$$|q_{n+1}(x)| \leqq h^{r+1}C_1 \cdot \max \left|\frac{d^{r+1}}{dx^{r+1}} q_{n+1}(x)\right| + C_2\rho + LhC_3\sigma$$

$$(x_{n-r} \leqq x \leqq x_n \text{ for max})$$

with constants C_1, C_2, C_3, which depend on r only. L is a Lipschitz constant for $f(x, y)$. H. Bückner, USA

1549. Vietoris, L., Truncation error of an approximative solution obtained by the Adams interpolation method in a system of the equation $y'_k = f_k(x,y_1, y_2, \ldots y_m)$ (in German), *Öst. Akad. Wiss. math.-nat. Kl. S.B.* IIa, **162,** 5/7, 293–299, 1953.

Author extends results of the paper reviewed above to systems of ordinary differential equations of first order. The new results are almost verbally the same, only the Lipschitz constant L of the previous paper is replaced by a matrix of such constants, the matrix operating on an error-vector $(\sigma_1, \sigma_2, \ldots, \sigma_m)$. Special attention is given to the case where the system stands for a single differential equation of higher order. H. Bückner, USA

1550. Siforov, V. I., On methods of computing reliability of operation of systems containing a large number of elements (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 6, 3–13, 1954.

In engineering there are widely applied systems which contain a large number of elements and which are characterized by damage to one of them resulting in failure of the whole system.

A typical example of such a system is the main line of a radio-relay line which contains a large number of intermediate stations each of which, in its turn, consists of a large number of electron tubes and other details.

In order to compute the reliability of similar complex systems for given properties of the individual elements, for example the tubes, it is necessary to have a quantitative relation connecting the probability of damage of the whole system to the probability of damage to its elements.

In the present work, there is formulated the problem of finding such numerical relations and to give methods, based on them, of computing the reliability of operation of a system containing al arge number of elements.

From author's summary by M. D. Friedman, USA

1551. Lampkin, R. H., Validity of test items that involve finding a pattern in data, *Scientific Monthly* **80, 1,** 50–56, Jan. 1955.

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 1689, 1751)

1552. Rauh, K., Practical science of mechanisms. 2. **The chains of wedges [Praktische Getriebelehre, Bd. 2. Die Keilkette], 2nd rev. ed. (edited by Rauh, W. K.),** Berlin, Springer-Verlag, 1954, vii + 172 pp., 128 pp. of figs., 4 tables. DM 43.50.

An important work, first published in 1939, now appears in an enlarged second edition. The principal additions are in the field of reversing mechanisms, pairing of mechanisms, precision of mechanisms, springs, and a set of graphs to aid in design. This is a rich compendium and description of mechanical devices with illustrations of their applications in industry. Except for a few equations of the computing mechanisms, there is no mathematics.

The first volume was devoted to the four-bar linkage and its extension to all linkages. This volume is devoted to the three-element wedge chain and its extension to include all other mechanisms. Slide transmissions are generalized to screws, flat cams, and helical cams. Locking devices include stepping mechanisms, ratchets, and intermittent gears. Couplings include universal joints of various designs, flexible and adjustable couplings, and clutches. Gear drives include pin gears, spur and bevel gears, and various gear trains. Friction drives include belt drives, and various combinations of the ball, disk, cone, and plate. Under computing are the analog mechanisms of linkage, slide, and friction drives as well as the digital devices of the desk calculator.

M. Goldberg, USA

1553. Artobolevskiĭ, I. I., Zinov'ev, V. A., Vyach, A., and Edel'shtein, B. V., Collection of problems on theory of mechanisms and machines [Sbornik zadach po teorii mekhanizmov i mashin], 2nd ed., Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1951, 195 pp.

Many recent Russian textbooks on mechanisms do not contain problems needed for the engineering student. The present work fulfills this need. Answers are given in the back of the book and, depending upon the demands of the problem, are qualitative, numerical, or graphical. The arrangement is by topic, following the works of the senior author. Each set of problems is preceded by a brief discussion of the general principles. The following topics suggest the scope of the work: kinematic pairs, composition of mechanisms, classification, degrees of freedom, trajectories, velocity and acceleration diagrams, centrodes, toothed mechanisms, design of mechanisms and cams, forces, friction, balancing of rotating mechanisms. M. Goldberg, USA

1554. Freudenstein, F., Approximate synthesis of four-bar linkages, ASME Fall Meet., Milwaukee, Wis., Sept. 1954. Pap. 54—F-14, 18 pp.

A four-bar linkage ABCD with $|AB| = b$, $|BC| = c$, $|CD| = d$, $|AD| = 1$ and with the angles $\phi = \pi - \sphericalangle BAD$, $\psi = \sphericalangle ADB$ is considered. The relation $R_1\cos\phi - R_2\cos\psi + R_3 = \cos(\phi - \psi)$; $R_1 = 1/d$, $R_2 = 1/b$, $R_3 = (1 + b^2 + d^2 - c^2)/(2bd)$ defines functions $y = f(x)$ which the linkage permits to represent rigorously in the parametric form $y = (\psi - \psi_0)/r_\psi$, $x = (\phi - \phi_0)/r_\phi$ with $r_\phi r_\psi$ as scale factors and with ϕ_0, ψ_0 as angles which represent $x = 0$, $y = 0$. In order to approximate a given function $g(x)$ by one of the functions $f(x)$, a suitable choice of the seven parameters $b, c, d, r_\phi, r_\psi, \phi_0, \psi_0$ is made according to either one of the following methods: (a) $g(x)$ and its approximation have the same values for a given number of abscissae (precision points); (b) $g(x)$ and its approximation coincide at a given abscissa together with the values of their derivatives up to a given order. The author presents tables for the calculation of the parameters. These cover 3, 4,

and 5 precision points and derivative coincidence up to order 7. Some diagrams refer to the log, the squaring, and the tangent function. H. Bückner, USA

1555. **Wunderlich, W., A remarkable twelve-bar linkage** (in German), *Öst. Ing.-Arch.* **8,** 2/3, 224–228, 1954.

If a twelve-bar linkage has the form of a parallel projection of a cube onto a plane, it is composed of six parallelograms and it has two degrees of freedom. This linkage can be passed through transition stages to assume a position in which two, three, four, or six parallelograms are replaced by crossed parallelograms (antiparallelograms). In the cases of three or four crossed parallelograms, there is only one degree of freedom.

M. Goldberg, USA

1556. **Rozovskiĭ, M. S., Selection of schemes of toothed reduction gears consisting of two differential three-member mechanisms** (in Russian), *Doklađi Akad. Nauk SSSR (N.S.)* **96,** 701–704, 1954.

Two planetary differential gear systems, in each of which the two inputs and the output have a common axis of rotation, are combined to produce a more elaborate gear train in which the two inputs and the output are again coaxial. The additional parameters permit a selection, to suit a particular need, from a richer collection of possible rational transmission ratios. For any given set of gear pairs, the possible ratios are presented in a convenient graphical plot. M. Goldberg, USA

1557. **Kreĭnes, M., and Rozovskiĭ, M., The selection of schemes of toothed reduction gears consisting of three differential, three-member mechanisms** (in Russian), *Doklađi Akad. Nauk SSSR (N.S.)* **96,** 1117–1120, 1954.

The method in previous paper (see preceding review) is extended to combination of three planetary differential gear systems.

M. Goldberg USA

1558. **Brumberg, R. M., Dynamics of a differential gear with three rotating masses** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **17,** 207–213, 1953.

General equations are derived for relations among external moments, moments of inertia, velocities, and accelerations of three rotating masses connected by differential gearing. Effects of dry (Coulomb) friction are included.

Example is given of planetary gear train, driven through mass 1, in which mass 3 begins to move when brakes are applied to mass 2. Equations derived in article are applied to plot resulting velocities vs. time. T. P. Goodman, USA

1559. **Bowden, F. P., Recent studies of metallic friction,** *Instn. mech. Engrs.*, 9 pp., 4 plates, 1954.

Author concludes his delivery of the 41st Thomas Hawksley Lecture thus: "...The engineer would like to run bearings and to slide surfaces at 1000 C and at very high speeds. Why should he not? It means that new and unconventional surfaces and lubricants must be developed. A fuller and more detailed understanding of the physics of the sliding process under these extreme conditions will help to do this, and the problem, particularly with the advent of atomic power, is an urgent one." There will be general agreement with author's sentiment that the greatest help which the physicist can give the engineer in this field is by endeavoring to elucidate the friction between solid bodies.

Often the actual area of contact is a very small proportion of the nominal area of contact. The use of radioactive indicators for showing material transfer at frictional contacts is mentioned. The surface temperature is determined by the equilibrium between the heat generated by work against the force of friction and the heat dissipated from the actual area of contact by conduction and convection, and possibly radiation. A cathode-ray trace of electric discharges is reproduced but is ascribed to "thermal potential difference developed between a Constantan slider on lapped steel surfaces." Polytetrafluoroethylene is described as a "low-friction material." The practice of using waxed ski was always to prevent "blotting action" by porous wood. Presumably a less brittle impregnating coating can be obtained with P.T.F.E. An interesting adaptation of the Beams centrifuge to high-speed braking is described. Evaluation of deceleration experiments is always difficult. It appears as if, between 800 mph and 1500 mph, average "coefficient of friction" was of order of 0.3. The concluding sentence of this chapter reads: "If only one could move fast enough one might perhaps ski on copper mountains!"!!

Experiments are mentioned with graphite in a high vacuum at 2000 C, and Dr. Tabor's work on rolling friction is discussed.

R. Schnurmann, England

1560. **Virabov, R. V., Three-dimensional theory of wedges as applied to conical couplings and friction drives** (in Russian), *Akad. Nauk SSSR Trudi Sem. Teorii Mash. Mekh.* **14,** 53, 20–46, 1953.

Author states that, for friction wedge drive (vee belts, etc.), maximum transmitted torque is not represented by equations of the $T = \mu Q/(\sin\alpha + \mu\cos\alpha)$ or $T = \mu Q/\sin\alpha =$ variety (Q is force normal to T, α half of included wedge angle). Based on three-dimensional considerations, author derives equation $T = (\mu Q_0/\sin\alpha)[1 - k_1\mu\cos\alpha/(k_1 + 2k_2\sin^2\alpha)(\sin\alpha + \mu\cos\alpha)]$ where k_1 and k_2 are stiffness of vertical and horizontal springs acting on wedge and Q_0 the (normal) load. With $\alpha = 10$ to $15°$, $\mu = 0.2$ and $k_2 = 8$ to $15\ k_1$, values of T are half way between values due to above two earlier equations. Use of new equation is illustrated for conical clutches, vee belt drives, and infinitely variable conical chain drives. Paper concludes with brief data from static rig tests.

In reviewer's opinion, while theoretical conclusions merit consideration, further experimental work is indicated before results can be adopted in practice, particularly in view of scatter of μ values. J. L. Koffman, England

1561. **Hély, J., Dynamics of the spinning mass point** (in French), *Mém. Artill. fr.* **26,** 4, 859–871, 1952.

In connection with this work, see the paper prepared by the same author, published previously in title source, **24,** 4, 1950, in which are given the fundamentals of relativistic dynamics of the spin-endowed material point.

In the present work, after writing the trajectorial equations for the spinning mass, in terms of relativistic dynamics, the author uses operator techniques to derive and discuss the equations. Particular attention is given to consideration of Dirac's "four-vector spin." A. Pignedoli, Italy

1562. **Flügge, W., and Coale, C. W., The influence of wheel spin-up on landing-gear impact,** *NACA TN* 3217, 107 pp., Oct. 1954.

Paper begins with an oversimplified setting for the purpose of pointing up the several phases of the problem. It turns out that the basic problem needs a four-phase breakdown. They are: (1) The ground-dragwise deflection and preliminary wheel spin-up of the gear before shock strut depression occurs. (2) The ground-dragwise deflection and wheel spin-up during shock strut depression. (3) The gear motion during nonskid roll up to the point of maximum shock strut depression. (4) The gear motion after phase 3.

The first three items are developed in detail while the fourth is declared currently beyond rational analysis. Phase 1 is solved in closed form from a linear differential equation, while 2 and 3, reduced to nonlinear equation, must be treated by numerical or quasi-numerical methods. The numerical methods offer alternatives of precise and approximate results, depending upon the requirements of a given case, while the quasi-numerical method offers quick precise results to skilled technicians. Detailed results and computative routines are presented for the symmetrically mounted wheels and vertical shock struts. Formulas are developed for offside wheel mountings and for inclined shock struts. Unfortunately, no comparison with measured values are presented. Also, it would have been interesting to have some generalized results covering such things as the specific influence of touchdown attitude. M. G. Scherberg, USA

1563. Hannah, Margaret, Applications of a theory of the spinning balloon—II, *J. Text. Inst. Trans.* **46,** 1, T1–T16, Jan. 1955.

Accuracy of author's previous analysis of the balloon formed in yarn spinning [title source, **43,** T519, 1952] is assessed with respect to more complete analyses of Mack [ibid., **44,** T483, 1953] and of Crank [*Text. Res. J.* **23,** 266, 1953]. The agreement is found to be good for practical conditions of cap spinning. The theory is then applied to predict size, shape, and tension of balloon. A speed regulator can be designed to allow constant tension spinning by varying spinning speed as bobbin fills. Much more simply, a specific cap shape can be devised to produce nearly constant balloon tension for all bobbin sizes. Experimental studies on wool spinning with such caps showed that the usual drop in tension during filling of a bobbin is decreased considerably.

D. J. Montgomery, USA

Servomechanisms, Governors, Gyroscopics

(See also Revs. 1701, 1706, 1784)

1564. Schmidt, S. F., and Triplett, W. C., Use of nonlinearities to compensate for the effects of a rate-limited servo on the response of an automatically controlled aircraft, *NACA TN* 3387, 27 pp., Jan. 1955.

Authors discuss means for determining a nonlinear amplifier characteristic to compensate for the effects of rate-limited control. By making the slope of the error amplifier output characteristic decrease with increasing error, stability is maintained for large commands without jeopardizing the speed of response for small commands. R. M. Stewart, USA

1565. Andrew, G. M., Controlled motion with time lag in autopilot, *J. aero. Sci.* **21,** 5, 346–347, May 1954.

The equations developed apply to a second-order system with arbitrary initial conditions, controlled by the autopilot. The method illustrated on one degree of freedom can be readily adapted for two or three degrees of freedom.

From author's summary

1566. Bekey, G. A., and Ahlin, J. T., Differential analyzer study of a nonlinear hydraulic servomechanism, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-4, 14 pp.

Author explains the advantage of using the differential analyzer to study an aircraft elevator control system for which motion equations are complicated owing to their sensitivity to nonlinearities of their components. A short description of the system is given and the problem is stated, developing the equations about three axes of rotation, where the constants and functions representing discontinuities are obtained experimentally. Two equations of linear displacements in terms of angular displacements are introduced. Author gives the machine solution in the form of time histories of the displacements and velocities. Frequency response behavior in resonance, removing of spring, and variations of damping and friction constants are studied.

Even though there are several computers possessing greater speed or accuracy, differential analyzer is very useful in problems where differential equations of motion have experimental and nonlinear constants. R. R. Hertig, Argentina

1567. Nichols, B. R., Modern trends in the design of hydraulic turbine governors, ASME Fall Meet., Milwaukee, Wis., Sept. 1954. Pap. 54—F-17, 11 pp.

1568. Evangelisti, G., On the regulation of hydraulic turbines [La regolazione delle turbine idrauliche], Bologna, Nicola Zanichelli, Editore, 1947, xvi + 276 pp.

This book studies the problem of the regulation of hydraulic turbines by considering all the installation elements, namely, the machine with the governor, the hydraulic system, and electric power net, so as to take into account—in research on the stability conditions of operation—the reciprocal interferences between the various parts during the unsteady operation phase.

After having described the principal schemes of regulation of the installations studied, the author evaluates, for each of these schemes, the equations of motion, namely, (a) of the motor-governor assembly, by assuming the inertia and the insensibility degree of the governor both equal to zero; (b) of the hydraulic system, by assuming the fluid to be incompressible and the walls of the duct to be rigid.

In second part of the book, the equation for small oscillations are written, both on the hypothesis of incompressibility of the water, and by taking into account the perturbation in the liquid duct as well as the elasticity of the latter's walls (according to the results of the Allievi theory). In both cases, the author applies the method of the Laplace transform to solve the equations. (The reviewer observes that the equation of the variable motion of the motor unit would have been more easily and more correctly written by applying the theorem of the moment of momentum with respect to the axis of revolution, instead of the energy theorem; because if the equation for small oscillation of the motor unit is to reduce to that given by the author, it is necessary that the efficiency should be constant and that the reaction of the electric unit driven by the turbine be reduced only to the inertia actions of rotating masses [see instead, Den Hartog, "Mechanische Schwingungen"]. Further, the solution of the characteristic equation, obtained by substituting for the hyperbolic sine and cosine the first n terms of the development of the same function in the form of an infinite product, is valid only as a method by trial, since it is obviously necessary to verify, after having evaluated the roots, that for the values of these roots the afore-mentioned functions vary only little with respect to the polynomials which have been substituted for them.)

The formulas are applied by the author to the study of the regulation of (a) plants with invariable motor head, (b) plants with inlet and outlet conduits under pressure, (c) plants with oscillation (compensating) tank.

For each of these three types of plants, the conditions of stability are given as well as the formulas for study of the stabilizers (accelerotachimetric governor, or governor with compensating dashpot); numerical applications are given in full.

The last chapter is dedicated to a study of the large variations in running conditions, for which author shows how the equations of motion are solved by the known procedures of step-by-step numerical integration.

Owing to the importance of the subjects dealt with, as well as the thoroughness of their development—as far as the hydraulic part is concerned—the book makes a considerable contribution to the study of the problem of regulation of hydraulic turbines.
C. Ferrari, Italy

1569. **Troitskiĭ, V. A., On the behavior of dynamical systems and systems of automatic regulation having several regulating organs near the boundary of a region of stability** (in Russian), *Prikl. Mat. Mekh.* **17**, 6, 673–684, Nov./Dec. 1953.

It was shown by N. N. Bautin ["Behavior of dynamical systems near the boundary of their region of stability," Gostehizdat, Moscow, 1949] that the question described in the title of his paper was reducible to the investigation of the critical systems of Lyapunov ["Problème générale de la stabilité du mouvement," Princeton, 1947], where there is either a single zero characteristic root or else one pair of pure complex such roots. Everything then depends, according to Lyapunov, upon the parity of the lowest terms of a certain power series and upon the sign of a certain number g. A similar result was obtained for automatic control systems with a single regulating element by A. I. Lur'e [AMR **4**, Rev. 1920; also "Some nonlinear problems in the theory of automatic controls," Gostehizdat, Moscow-Leningrad, 1951]. This is now extended to automatic control systems with several regulating organs. Explicit expressions are actually given for the number g.
S. Lefschetz, USA

1570. **Nishihara, T., Sawaragi, Y., and Sawamura, T., The effect of saturating characteristic and dead zone in the relay of an automatic controller on stability,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 633–637.

Nonlinear characteristic of hydraulic valve is approximated by linear expressions. Assumption is made that such approximation permits linear stability criteria to accurately apply. Data, derived from analyses of undisclosed systems, are presented purporting to support this assumption. Conclusions are drawn regarding effect on stability of dead zone and saturation phenomena in the valve characteristic. In reviewer's opinion, these conclusions are unsupported.
L. Becker, USA

1571. **Hadekel, R., Hydraulic and pneumatic servos. Part I. General servo theory,** *Automation* **1**, 3, 57–66, Oct. 1954.

1572. **——, Part 2. Improving servo performance,** ibid., 1, 4, 49–58, Nov. 1954.

1573. **——, Part 3. Basic servo elements,** ibid., **1**, 5, 43–52, Dec. 1954.

1574. **——, Part 4. Flow control with valves and pumps,** ibid., 2, 1, 61–69, Jan. 1955.

1575. **——, Part 5. Analysis of pump and valve servos,** ibid., 2, 2, 49–58, Feb. 1955.

1576. **——, Part 6. Complex servos,** ibid., 2, 3, 65–74, Mar. 1955.

Vibrations, Balancing

(See also Revs. 1691, 1852)

1577. **Caughey, T. K., The existence and stability of ultraharmonics and subharmonics in forced nonlinear oscillations,** *J. appl. Mech.* **21**, 4, 327–335, Dec. 1954.

Approximate expressions for periodical solutions of equations

$$\ddot{y} + k\dot{y} + \omega_0^2 y + \mu y^3 = P \cos (\Omega t + \alpha) \quad [1]$$

(k, μ small parameters, $k > 0$) are obtained by methods of nonlinear mechanics. In the expression for the periodic solution of frequency Ω the predominant term is harmonic of frequency Ω, if Ω is close ω; harmonic of frequency 3Ω (ultraharmonic solution) if Ω is slightly greater than $\omega/3$. Eq. [1] under suitable conditions also has subharmonic solutions of frequency $\Omega/3$. Stability of these solutions and jump phenomena are discussed; subharmonic solutions are stable only for a particular set of initial conditions.
D. Graffi, Italy

1578. **Popov, E. P., On approximate investigation of auto-oscillations and forced oscillations of nonlinear systems** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **95**, 943–946, Apr. 1954.

Application of the Krîlov-Bogolyubov type of linearization by harmonic balance to a wide variety of nonlinear systems in two variables.
S. Lefschetz, USA

1579. **Andersen, B. W., Vibration of triangular cantilever plates by the Ritz method,** *J. appl. Mech.* **21**, 4, 365–370, Dec. 1954.

Author extends work of Young [AMR **4**, Rev. 1929] and Barton [AMR **4**, Rev. 4079] on the vibration of cantilever plates to the determination of a few of the lower natural frequencies and corresponding node lines of four isosceles triangular plates clamped at the base and three right triangular plates clamped along one leg. The Ritz method is employed. Reasonably good comparison is obtained between calculated and experimental frequencies. Some of the conclusions presented by author will be of interest to those engaged in computing natural frequencies of triangular cantilever plates.
J. L. Bogdanoff, USA

1580. **Gustafson, P. N., Stokey, W. F., and Zorowski, C. F., The effect of tip removal on the natural vibrations of uniform cantilevered triangular plates,** *J. aero. Sci.* **21**, 9, 621–633, 648, Sept. 1954.

Experimental results are obtained for the lowest six natural frequencies and the associated nodal lines of trapezoidal plates of uniform thickness clamped on one edge. Three series of plates are investigated. Each series consists of six plates and is developed from a triangular plate by progressively cutting off portions of its tip parallel to its clamped edge, giving a clipped wing effect.

Results are presented in the form of graphs, tables, and photographs. A method of treating plates of nonisotropic material is described. The use of interpolation to extend the results to a broader field of plate shapes is also discussed.
From authors' summary by A. I. Bellin, USA

1581. **Warburton, G. B., The vibration of rectangular plates,** *Proc. Instn. mech. Engrs.* **168**, 12, 371–381, 1954.

The analysis is based on the ordinary theory of thin plates and uses Rayleigh's method to determine frequencies. The modal shape is represented by the product of the characteristic functions for two beams with appropriate end conditions. For the higher modes, the method assumes that the nodal pattern of the vibrating plate consists of lines parallel to the sides.

An approximate formula is derived which expresses the frequency in terms of the nodal pattern, the plate dimensions, and a group of coefficients which depend on the boundary conditions. Values of these coefficients are tabulated for 15 different combinations of boundary conditions. Accuracy of the frequency formula is assessed by comparing results with those of more precise analyses, where such exist. A discussion is given regarding possible nodal patterns. A concise summary of previous work dealing with the vibration rectangular plates is included, together with a good bibliography.
D. Young, USA

1582. Černá, G., Longitudinal vibrations of anisotropic circular plates, *Bull. Inter. Acad. Tchèque Sci.* 52, 2, 321–360 (1951), 1953.

The problem is that which arises in the vibrations of thin plates cut from quartz crystals. This investigation concerns those slices taken in an arbitrary direction with respect to the axis of the crystal. A brief review is given of the differential equations and boundary conditions for an anisotropic thin plate first presented by Voigt. A brief description of the methods used in the paper, mainly Galerkin's method and the method of successive approximations, is presented. In the case of the antisymmetric representation of the vibrational modes by fifth degree polynomials, a 12 × 12 determinant is found whose annihilation is required. The expressions for the elements of the determinant in the general case are quite lengthy. The simpler case of the use of a third-degree polynomial is also presented. Fourth-degree polynomials are used in the case of symmetrical vibrations.

Author uses these results in numerical examples to check with experiments on isotropic quartz plates and unpublished experimental results on anisotropic quartz plates obtained by Dr. E. Mikulaschek. Correlation between calculated and measured frequencies is in all cases less than 7.3%. A. L. Ross, USA

1583. Kurata, M., On vibration of continuous rectangular plates, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 561–566.

A study of free vibration of thin, elastic plates which are continuous in x-direction and simply supported in y-direction.

Intermediate edges, parallel to y-axis, are simply supported or, alternatively, jointed with perfectly smooth hinges placed at equal intervals. End edges, parallel to these edges, are either simply supported, or clamped, or free.

Respective frequency equations are deduced, and values of the lowest frequency are tabulated for several continuous plates having an edge length ratio $a/b = 0.5$, where a and b represent edge lengths in x- and y-directions. S. T. A. Ödman, Sweden

1584. Hall, A. H., Pinkney, H. F. L., and Tulloch, Helen A., On the analytical determination of the normal modes and frequencies of swept cantilever vibrations, *Nat. aero. Establ. Canad.* LR-76, 77 pp., 21 figs., July 1953.

An analytical method employing station functions is derived for the prediction of the normal modes and frequencies of vibration of swept cantilever plates. The station functions of Mendelson and Gendler deduced from the boundary conditions for an unswept cantilever plate are applied. The analysis employs basic reference directions in the wing plane which are parallel and normal to the direction of flight. The use of such coordinates simplifies the dynamic calculations in a practical case because the acute-angled wing tip requires no special treatment and because the center line of concentrated masses such as nacelles and tip tanks, as well as their stiffening structure, will be parallel to the aircraft center line.

Experiments are described for the determination of the vibration mode shapes and frequencies of uniform swept cantilever plates. The agreement between theory and experiment can be said to be satisfactory for engineering purposes. A sweep angle of 60° probably represents an upper limit of applicability of the theory. R. L. Bisplinghoff, USA

1585. Watanabe, I., On natural frequencies of flexural vibration of trapezoidal cantilever with uniform thickness, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 541–545.

The elementary equation for the free vibration of a tapered beam is solved in terms of hypergeometric functions. The frequency equation for the cantilever beam is determined by neglecting higher-order terms of the functions and is expressed as a fourth-order determinant in which the taper factor appears explicitly.

A numerical evaluation for the fundamental frequency as a function of taper indicates close agreement with values previously obtained by the Rayleigh method. M. V. Barton, USA

1586. Sawaragi, Y., and Yosomiya, R., Graphical solution of the problem of forced vibration of a vibrating system of two degrees of freedom with arbitrary non-linear restoring forces (3rd Report), *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 625–631.

Amplitude vs. frequency curves for a specific system involving restoring forces of the form $f(x) = kx + \beta x^3$ are derived experimentally and in a graphical version of usual analytical approach. Good agreement is shown. L. Becker, USA

1587. Konishi, I., and Goto, H., Vibration characteristics of bridge piers, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 577–581.

Paper deals with free vibration of a single bridge pier carrying a superstructure. Elasticity of foundation and frictional forces in and between various materials are taken into consideration.

Author uses Rayleigh's method for calculating the lowest frequency and assumes a deflection curve similar to that due to a horizontal force acting at top of pier. In determining ground reaction, two alternatives are considered: (a) ground reaction is proportional to displacement; (b) ground reaction increases linearly with depth of foundation, and stiffness of pier is at the same time infinite.

Some numerical examples are computed, and the results are compared with values obtained from measurements on multispan bridges. S. T. A. Ödman, Sweden

Wave Motion in Solids, Impact

(See also Rev. 1880)

1588. Goland, M., Wickersham, P. D., and Dengler, M. A., Propagation of elastic impact in beams in bending, *J. appl. Mech.*, 22, 1, 1–7, Mar. 1955.

See AMR 6, Rev. 3666.

1589. Anonymous, Proposed tentative method of test for the measurement of the pulse velocity of propagation of elastic waves in concrete, *ASTM Bull.* no. 204, 19–22, Feb. 1955.

The use of pulse velocity techniques to determine properties of concrete, long proposed by various investigators, assumed a practical aspect in 1945 upon the report of the development of an impact device suitable for measuring such velocities. Many organizations have investigated such devices since that time. Additional progress was reported in 1949 with the development of an electronic instrument, sometimes referred to as an "ultrasonic" instrument, for measuring velocities with, possibly, greater accuracy than the earlier impact device.

From summary

1590. Theisen, J. G., and Edge, P. M., Jr., An evaluation of an accelerometer method for obtaining landing-gear drag loads, *NACA TN* 3247, 22 pp., Oct. 1954.

An accelerometer method for obtaining landing-gear drag loads was evaluated with a small landing gear in the Langley impact basin. The method involves the use of an angular ac-

celerometer, in conjunction with linear accelerometers for the measurement of the time history of the wheel rotation and the landing strut displacement The drag loads were then obtained from information on angular acceleration of the wheel, the moment of inertia of the wheel, and the force-deflection relationships of the tire based on the measured tire radius. Good agreement was obtained between the results based on this method and those obtained simultaneously from dynamometers.

C. C. Wan, USA

1591. **Potter, D. M., An experimental investigation of the effect of wheel prerotation on landing-gear drag loads,** *NACA TN* 3250, 19 pp., Oct. 1954.

The results of this investigation indicate that both the drag load and the vertical load acting on a landing strut during landing impact can be reduced with prerotation of the landing wheel. The effect of prerotation on the maximum drag load was found to be the same as the effect of reducing the skidding velocity.

C. C. Wan, USA

1592. **Oberhettinger, F., Diffraction of waves by a wedge,** *Comm. pure appl. Math.* **7**, 3, 551–563, Aug. 1954.

Author reviews previous treatments of wedge diffraction problems by Macdonald, Bromwich, Sommerfeld, Carslaw, and others. In three sections are presented: (1) Green's functions of the wave equation for a wedge of arbitrary angle with a line source parallel to the edge; they are expressed in an integral form and evaluated. (2) A transformation of the integral which, in the special case when wedge is a half-plane, is shown to agree with a solution by Carslaw. (3) Adaptation of the two-dimensional solutions to deal with a point source.

Originality is claimed for the formulation in terms of Hankel functions rather than the results.

From author's summary by M. J. P. Musgrave, England

1593. **Vaněk, J., A contribution to the theory of elastic waves produced by shock** (in English, with Czech summary), *Czech. J. Phys.* **3**, 2, 97–119, June 1953.

Paper concerns elastic waves in an infinite, homogeneous, isotropic solid. Waves are produced in the initially undisturbed solid at a spherical source on the surface of which the distributed stress is an arbitrary function of time. The problem considered is reduced to a *quasi* two-dimensional one by an assumption of symmetry. General expressions are found for dilatation, rotation, and components of displacement at any point outside the source at any time after initiation of disturbance.

Special attention is paid to excitation of "explosive" character in which a purely radial stress pulse is applied at the source. Spatial distribution of pressure at source is specified in terms of Legendre polynomials; present paper is devoted to discussion of orders $n = 0$ and $n = 1$, while $n = 2$ will be dealt with at a later date.

This article is entirely theoretical. It is a significant contribution and is well written.

R. E. D. Bishop, England

1594. **Shimazu, Y., Propagation of elastic waves in a medium under finite initial strain** (in Japanese), *Zisin* (*Earthquake*) (2) **5**, 1–10, 1952.

Propagation of elastic waves in a medium under finite compression or shear is studied. The medium is assumed to be isotropic at the initial state. The theory of finite elastic strain proposed by F. D. Murnaghan is used. In this theory, the strain may be of any magnitude although it must be perfectly reversible and uniquely determined by the stresses.

Velocities of the waves are expressed in terms of the given compression or shear and of the elastic constants of the initially isotropic medium. Because of the apparent anisotropy, the waves propagated are polarized. It is concluded that the effect of initial strains upon the propagation of the waves is small. The velocity change will be at most 1% for the linear compression of 0.5% or for shear of 10 min.

From author's summary by K. Kasahara, Japan

Elasticity Theory

(See also Revs. 1593, 1594, 1616, 1635, 1636, 1637, 1646, 1652, 1814, 1865)

1595. **Conway, H. D., Note on the orthotropic half plane subjected to concentrated loads (Brief Note),** *J. appl. Mech.* **22**, 1, p. 130, Mar. 1955.

1596. **Adkins, J. E., Green, A. E., and Nicholas, G. C., Two-dimensional theory of elasticity for finite deformations,** *Phil. Trans. roy. Soc. Lond.* (*A*) **247**, 929, 279–306, Dec. 1954.

Plane stress theory of isotropic elastic plates is developed without restrictions on magnitudes of deformations or rotations. Strain energy density is regarded as an unspecified function of three strain invariants which are defined in terms of metric tensors for associated coordinate systems relating to strained and unstrained states. By energy principles, stress tensor is determined by strain energy density and metric tensors.

By means of tensor principles, theory is developed without designation of specific coordinates. Subsequently, a formulation in terms of complex variables is presented. Repeated approximation procedure is devised for solving specific problems. Theory runs parallel to an earlier theory of finite plane strain developed by Adkins, Green, and Shield.

Primary assumptions are that transverse normal stress is negligible and that displacement vector does not vary through thickness of plate.

H. L. Langhaar, USA

1597. **Mossakovskiĭ, V. I., Basic mixed problem of the theory of elasticity for semispace with a circular separation line of boundary conditions** (in Russian), *Prikl. Mat. Mekh.* **18**, 2, 187–196, Mar./Apr. 1954.

Paper is concerned with the solution of the basic mixed boundary-value problem of the theory of elasticity for semispace for the case when, on one part of the boundary (inside a circle) the components of the displacement vector are prescribed, and on the remaining part the components of traction. As an example of the method described, the problem of symmetric pressure of a plane circular die is solved by the method developed by N. I. Muskhelishvili.

G. Herrmann, USA

1598. **Das, S. C., On the stresses due to a small spherical inclusion in an elastic solid under uniform shearing stress,** *Indian J. theor. Phys.* **1**, 4, 171–182, Mar. 1954.

The stress distribution in an infinite isotropic elastic solid containing a small spherical inclusion and under uniform shear stress at a great distance is found by setting up the equations of equilibrium in polar coordinates. Particular solutions for the inclusion and the region outside of the inclusion are found. At the boundary between them the appropriate conditions on the displacements and stresses are introduced and the general distribution of stress is obtained. Calculations are given for the special cases where the inclusion (a) becomes a cavity, (b) is perfectly rigid, and (c) has the same Poisson ratio as steel but is only one quarter as rigid.

E. Saibel, USA

1599. Jindra, F., Some applications of a nonlinear elasticity law (in German), *Ing.-Arch.* **22**, 2, 121–144, 1954.

A detailed theoretical study of Kauderer's generalization of Hooke's law [title source, **17**, 450, 1949], which includes nonlinearity even when the sample is only infinitesimally strained, as occurs in some materials. Investigation is entirely by example; e.g., rectangular plate under tension and shear, circular plate under symmetrical compression, and others. Author uses perturbation technique and power series expansion with the linear case as leading term whenever exact solution is not possible. Numerical results obtained from these examples exhibit deviations from linear behavior of up to 15%, even though the deviation from Hooke's law is quite small. A. Leitner, USA

1600. Stahl, K., Solution of elasticity problems in complex and hypercomplex representation (in German), *Ing.-Arch.* **22,** 1–20, 1954.

Author presents a partially expository treatment of the representations, in plane elasticity problems, of stress in terms of functions of complex and hypercomplex variables, showing, among other things, that these are simply related to each other. Representations valid in orthogonal curvilinear coordinates are given. These are used to obtain solutions of boundary-value problems for several types of regions. Techniques for obtaining approximate solutions for essentially arbitrary regions are briefly outlined. Numerous references to relevant literature are included.

J. L. Ericksen, USA

1601. Brdička, M., The equations of compatibility and stress functions in tensor form (in Czech), *Czech. J. phys.* **3**, 36–52, March 1953.

In this paper, new uses of tensor calculus in elasticity are given, concerning principally the equations of compatibility and the integration of the equation of equilibrium by means of the stress functions.

The equations of compatibility for deformation (Saint Venant's equations), given in Cartesian coordinates in a simple tensor form, are first derived. From this, using a simple process, are derived the equations of stress compatibility in their usual form (i.e., Beltrami's equation). Various solutions of the equation of equilibrium are then derived in a simple way with the help of the stress functions, i.e., Galerkin's solution and Papkovič-Neuber's solution, as well as Krutkov's solution which, as a special case, comprises Maxwell's and Morera's solutions.

In the following part of the paper it is shown how it is possible to transform the previous results to general orthogonal coordinates, i.e., to the covariant form; in doing so, physical components of the vectors and tensors have to be introduced. The covariant form of equation is then given and it is shown how, from this, the equations for cylindrical coordinates derived by Odqvist follow by the direct elimination of the components of elastic displacements from equations. The covariant form of Beltrami's equations is given, along with Krutkov's solution.

From author's summary

1602. Berio, A., Finite deformation of elastic bodies (in Italian), *R. C. Semin. mat. fis. Milano* **23**, 164–181, 1953.

The indefinite relationships for equilibrium of elastic bodies under finite strain are set forth. Author is interested in analytic expressions for stress tensor components containing but odd powers of strain components. More particularly, only linear and cubic terms are included. Assuming existence of an elastic potential, he describes necessary modifications of elementary theory of homogeneous isotropic bodies.

F. K. G. Odqvist, Sweden

1603. Lur'e, A. I., Stresses in an elastic cylinder with a lateral surface load (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **17,** 43–58, 1953.

Paper presents solution of the axisymmetrical problem of stresses and displacements in a solid cylinder loaded on the outside surface over a part of its length with normal uniform load. The solution is based on general equations of the theory of elasticity in cylindrical coordinates under the conditions of axisymmetry. The results are expressed in terms of infinite series, which are quickly damped away from the loaded region. The problem of circumferential line loading is obtained from the general case by reducing the loaded length of the cylinder to zero.

A. Hrennikoff, Canada

1604. Podstrigach, Ya. S., Stresses in a plane weakened by two unequal circular openings (in Ukrainian, with Russian summary), *Dopovidi Akad. Nauk Ukrain. RSR* **1953**, 456–460, 1953.

Bipolar coordinates are used to investigate the stress concentration in an infinite elastic plane weakened by two unequal circular openings. Special consideration is given to two examples: (a) the circular contours are subjected to uniform but unequal pressures; (b) the plane is in the state of biaxial tension and the circular contours are free of external forces.

I. S. Sokolnikoff, USA

1605. Segawa, W., Simple application of the theory of rubber-like elasticity, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 11–14.

Author gives solution to three plane stress problems: (1) thin rectangular plate; (2) thin circular plane; (3) rotating disk. The material in each case is assumed to behave according to a Hooke's law for rubber along with the usual volume constancy relation. By assuming the nature of the displacements in each case, the author is led to the type of boundary stresses necessary to sustain the displacements. The results are, of course, valid for large deformations. M. Stippes, USA

1606. Malinin, N. N., Calculation of a rotating, nonuniformly heated disk of variable thickness (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **17,** 151–162, 1953.

Method is presented for calculating stresses, within the elastic limit, taking into account the radial variation of Young's modulus and Poisson's ratio with temperature. Disk is divided into annuli of constant thickness and constant material properties for each of which the solution is well known. In place of an explicit matching of stress and displacement boundary conditions at all annulus interfaces, author introduces auxiliary disk having bounding radii, temperature distribution, and loading of original disk, and thickness and material properties of innermost annulus. On cylindrical surfaces at radii corresponding to annulus junctions of stepped disk are applied fictitious radial loads of such magnitude that auxiliary disk has same radial displacement function as stepped disk. These boundary radial loads, and finally also the stresses, are expressed in terms of three parameters for which recurrence formulas are given. Numerical example is worked out. All bibliographical references are to Russian literature.

R. W. Gretter, USA

1607. Melan, E., Thermal stresses generated in rotating temperature fields (in German), *Öst. Ing.-Arch.* **8,** 2/3, 165–170, 1954.

The determination of the thermal stress field in a thin circular plate is considered for the case of a steady temperature field. The analysis incorporates the concepts of the theory of generalized plane stress. The problem arises in the design of gas-turbine blades. H. G. Hopkins, England

1608. **Glatzel, E., and Schlechtweg, H., Stress distribution in a cylindrical brittle tube under uniform internal and external pressure** (in German), *ZAMM* **34**, 3, 81–104, Mar. 1954.

The nonlinear law of elasticity introduced by Schlechtweg [title source, **14**, 1, 1934; *Ing.-Arch.* **4**, 263, 1933] is modified by assuming that bulk and shear moduli bear a constant ratio, though not remaining separately constant, and by neglecting a deviation from Hooke's law which is of higher order in the stress than the terms retained.

The problem of a hollow cylindrical tube under internal and external pressures is solved for this law of elasticity, first by using the radial stress as variable, and again using the radial displacement as variable. F. R. N. Nabarro, South Africa

1609. **Alfutov, N. A., Calculation of single-ply corrugated boxes (sylphons) by Ritz's method** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **15**, 181–186, 1953.

The case of axial load on the sylphon has been solved in a paper by Feodosiev. Present paper considers a half wave under internal pressure. The strain energy integral contains functions ϑ and v_0, being the angular rotation of an element and the radial displacement, respectively. Analogy with a beam of small curvature has been worked out, ϑ and v_0 having been found from minimum energy conditions, and the curves of deflection and moment plotted. Maximum equivalent stress and its location have been determined. P. Bielkowicz, USA

Experimental Stress Analysis

(See also Rev. 1685)

1610. **Characteristics and applications of resistance strain gages,** *Nat. Bur. Stands. Circ.* 528, iv + 140 pp., Feb. 1954. $1.50.

A collection of eleven papers by twelve authors about resistance strain gages given at the Semicentennial of the National Bureau of Standards, November 8 and 9, 1951. These papers present some of the results, both experimental and theoretical, in the study and application of resistance strain gages current in 1951. The subject matter is quite diverse and contains information about Poisson's ratio for elastic and plastic strains in tension, cementing and waterproofing resistance-type wire strain gages, Statham unbonded wire strain gage principles, measurement of internal strain in concrete, properties of concrete under impact as measured by bonded wire strain gages, transverse sensitivity of wire gages, the Swedish wire strain gage called G—H gages, use of bonded gages in the field of instrumentation, commercial weighing with resistance strain gages, wire strain gages applied to high capacity load calibrating devices, investigations about the strain sensitivity of conducting films.

For any one working in the field of experimental stress analysis, this collection of information has much of considerable interest and value. This is particularly so for problems similar to those mentioned as discussed in the book.

C. O. Dohrenwend, USA

1611. **Hiltscher, R., Theory and application of photoelasticity in the elastoplastic region** (in German), *ZVDI* **97**, 2, 49–58, Jan. 1955.

First of all, author describes a number of experiences with polarized light, where he has examined some parallelepipeds of polystyrol under the action of different forces. These experiences prove that the material in question is strained according to laws analogous to those describing the deformation of metals. Because of this property, it is possible to study certain phenomena of plasticity of metals by using models of polystyrol. Especially in plane stress and plane strain, the beginning and the evolution of the perfectly plastic zones and the retrogression of the perfectly elastic zones can be observed. Author also describes different applications of this method. H. Favre, Switzerland

1612. **Beth, R. A., and Meeks, W. W., Magnetic measurement of torque in a rotating shaft,** *Rev. sci. Instrum.* **25**, 6, 603–607, June 1954.

In a cylindrical shaft under pure torsion, the principal stress lines are 45° helices around the axis, one for tension and the other for compression. These are also the directions of maximum and opposite permeability changes for a shaft of magnetostrictive material. Based on these ideas, a magnetic torque-measuring device has been devised and tested. It consists of an external magnetic yoke carrying a driving coil and pickup coils on each of several branches to detect the permeability changes in flux paths lying in or near the principal stress directions in the shaft. Linear response, good sensitivity, and fair stability have been obtained with rotating shafts. From authors' summary

Rods, Beams, Cables, Machine Elements

(See also Revs. 1552, 1553, 1556, 1557, 1560, 1579, 1584, 1585, 1588 1663, 1667, 1682)

1613. **Klöppel, K., and Weihermüler, H., Nonuniformity of stresses in prestressing cables** (in German), *Stahlbau* **23**, 4, 77–80, Apr. 1954.

Paper discusses the slackening of stresses in prestressed steel members that change direction, and lose tension by friction at the points of direction change. Authors call attention to the influence of vibrations on the stress distribution in such members.

Experimental results are compared with an analysis based on the decrease of tension in a cable rolled on a cylinder of given radius. Authors show the incorrectness of the calculation procedure which assumes equality of the stresses at the two ends of a cable prestressed from only one end. In symmetrical stretching, similar discrepancies arise.

Authors also prove that it is not possible to eliminate the nonuniformity of stresses even by applying an initially higher stress, and then by slackening. On the contrary, slackening of the stressed end causes great variation in the force distribution for differently directed cable lengths. They show experimentally that the stresses can be made uniform only by vibrating the structure, or by a smilar procedure.

Reviewer agrees with authors that special constructional techniques are required to control the stresses in prestressing cables which change direction, and also that design procedure should take into account the stress variations which may occur in elements of the type under consideration.

J. Delpini, Argentina

1614. **Yasoshima, Yoshinosuke, On the stresses in rail webs** (in Japanese), *J. Japan Soc. civ. Engng.* **38**, 12, 527–531, Dec. 1953.

With some simplifying assumptions, the equations of the bending combined with torsion of a rail are reduced. When a rail is fixed at both ends and (a) a couple and a vertical force, (b) a couple and a horizontal force are applied at the center of its span, the relation between the vertical tensile stress in web and the torsional moment, and the manner of stress distribution in the web are well confirmed by author's theory. In addition to stresses which are expected by his theory, the other unexpected ones widely distributed along the rail are observed in rails which are under actual railroad service. T. Mogami, Japan

1615. Schade, G., Derivation of an equation for the design of shaft of fans, and comparison of shaft with different shape (in German), *Maschinenbau-tech.* **3**, 4, 183–186, Apr. 1954.

Shaft under consideration is supported at the ends, loaded by a concentrated force in the middle and by its own weight. Most of the five shafts are of technical importance. By elementary means author derives design formula, taking into consideration strength and critical speed. W. L. Esmeijer, Holland

1616. Nakazawa, H., Torsion of a shaft which has a number of longitudinal notches on outer or inner boundary, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 209–214.

Knowledge of the conformal transformation which maps a rectangular area of the ω ($=\alpha + j\beta$)-plane on an area S of the z-plane enables calculation, by well-known elasticity theory, of the stress function, shearing stresses, and torsional constant of a torsed homogeneous isotropic cylinder of uniform cross section S.

Now under the transformation $z = s(\cos\omega)^{1/m}$, whereof $m = \pm(1 + 0.5n)$ and $n = 0, 1, 2, \ldots$, and for appropriate choice of the parameter β, the area S approximates: for $m > 0$, an annulus with outer circular boundary and inner boundary a circle indented with $2m$ notches; and for $m < 0$, a full circle indented with $2|m|$ notches.

For such shapes, which approximate the cross sections of serrated and splined shafts, the author determines the general expressions for the afore-mentioned torsional quantities; illustrates calculation therewith through several numerical examples; and plots families of curves of stress concentration factor [= (*notch stress/stress at same maximum radial point of a circular shaft*)] as a function of the number of notches. Finally, a table of data pertinent to calculation of shafts with cross sections S approximating those of splined and serrated shafts actually used in practice is advanced. T. J. Higgins, USA

1617. Beggs, J. S., Synthesis of the surfaces of friction skew gears, *J. appl. Mech.* **22**, 1, 11–12, Mar. 1955.

The general problem of transmitting motion between two shafts with uniform velocity is discussed in this paper. The methods used to synthesize the teeth of spur gears have been extended to three dimensions. While the present paper is limited to a discussion of friction gears, the groundwork is laid for attacking the problem of toothed skew gears. Skew friction gears are shown to slip even under no load and therefore would appear to have a very limited usefulness. From author's summary

1618. Reswick, J. B., Dynamic loads on spur and helical-gear teeth, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-9, 10 pp.

It has long been known that heavily loaded gears, particularly at low speeds, have the expected life-load characteristics, but that high-speed lightly loaded gearing has a much lower life than would be expected from the nominal tooth loading; this discrepancy is due to the dynamic increment, and the use of speed factors and dynamic load increments is an attempt to allow for this effect. Author shows that from consideration of a simple physical model these effects may be estimated.

Heavily loaded gears are defined as those in which the sum of the tooth deflections σ_t due to the load is greater than the worst sum of spacing errors e_m; for these, the maximum dynamic increment load $T_i \ll {}^1/_2\, ek$, where e is the total effective error $(\sigma_t + e_m)$ and k is the tooth stiffness (lb/in. deflection). For very lightly loaded gears, $\sigma_t \ll e_m$, $T_1 \doteq 2v(kmec)^{1/2}$ provided this does not exceed ek, in which case $T_i \ll ek$; here m is effective mass of gears and c effective cam constant $= (1/R_p + 1/R_g) \tan\theta(1 - \cos\theta)/\theta^2$, R radius, θ pressure angle, v velocity.

E. M'Ewen, England

1619. Elonka, S., Packing (a dynamic seal)—a practical manual, *Power* **99**, 3, 107–130, Mar. 1955.

1620. Gatz, H., Wear of rubber-covered contact rings (in German), *ZVDI* **97**, 4, 109–112, Feb. 1955.

1621. Vissat, P. L., and Del Buono, A. J., In-plane bending properties of welding elbows, *Trans. ASME* **77**, 2, 161–171, Feb. 1955.

See AMR **7**, Rev. 2123.

1622. Markl, A. R. C., Piping-flexibility analysis, *Trans. ASME* **77**, 2, 127–143, Feb. 1955.

See AMR **7**, Rev. 2122.

1623. Markland, E., Influence lines for continuous beams, *Engineering* **178**, 4621, 242–243, Aug. 1954.

Plates, Disks, Shells, Membranes

(See also Revs. 1579, 1580, 1581, 1583, 1584, 1595, 1603, 1665, 1672)

1624. Negoro, S., On a method of solving elastic problems of plates, *Rep. Res. Inst. appl. Mech. Kyushu Univ.* **3**, 11, 115–128, Aug. 1954.

Author investigates influence of normal stresses perpendicular to the middle plane of a plate due to a load on its upper surface. Restricting the load distribution according to a plane harmonic function and assuming reasonable stress distribution along thickness, he deduces formulas for displacement and stress components in the three Cartesian coordinate directions. Suppressing mentioned stresses, he gets a well-known generalized plane stress state and further simple cases formerly derived by the author.

W. Mudrak, Austria

1625. Herzog, M., Computation of anisotropic plates with uniformly distributed load according to the strip method (in German), *Schweiz. Bauztg.* **72**, 32, 457–458, Aug. 1954.

1626. Saito, Hideo, On the stresses in statical and rotating circular plates having symmetrically placed eccentric holes (in Japanese), *Trans. Japan Soc. mech. Engrs.* **20**, 95, 473–478, July 1954.

A solution is described for the problems of generalized plane stress in a circular plate which contains many eccentric circular holes equally spaced on a radius. Using many sets of polar coordinates whose poles are centers of the plate and the eccentric holes, the appropriate Airy stress functions are derived first in terms of these coordinates. Then, by means of the relations between the coordinates, the stress function is expressed in terms of one appropriate coordinate system on the plate boundary and on the edge of each hole, and the coefficients contained in the stress function are determined by a set of conditional equations so as to satisfy the boundary conditions. As an example, stress distributions in a freely rotating circular disk are calculated for several cases of different size and number of holes.

T. Udoguchi, Japan

1627. Hardiman, N. J., Elliptic elastic inclusion in an infinite elastic plate, *Quart. J. Mech. appl. Math.* **7**, part 2, 226–230, June 1954.

Using complex variable methods, problem is solved for uniform stress at infinity. Plate and inclusion are isotropic with different elastic moduli. A. E. Green, England

1628. **Ishlinskiĭ, A. Yu., On a limiting process in the theory of stability of elastic rectangular plates** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **95**, 3, 477–479, Mar. 1954.

Note contains a rigorous justification of a surprising result obtained by the author in 1945 (no reference). It concerns the problem of stability of a rectangular plate under uniformly distributed compressive loading, acting on two opposite hinged edges, the two other edges (parallel to the loading) being free. In the limiting case of a very long plate, the buckling load is calculated to be, contrary to expectation, smaller than the one for a cylindrical form of loss of stability. A mathematical analysis reveals the reason for this behavior and the result is made physically plausible by stating that Saint Venant's principle is not applicable to plates under tension.

G. Herrmann, USA

1629. **Narodetskiĭ, M. Z., Stretching of a square plate with a cutout in the center** (in Russian), *Inzhener. Sbornik, Akad. Nauk. SSSR* **14**, 101–108, 1953.

Author studies the title problem for the important, practical case when the ratio of cutout diameter to the breadth of the plate is equal to 1. The solution for the torsion problem of a box with the analogical cross section is used, as obtained by the author and D. I. Sherman.

In order to simplify the problem, the square-shaped plate is replaced by a regular curvilinear rectangle. Complex function theory is used, and calculations are facilitated by numerical tables.

The solution may be applied also for smaller as well as larger values of the ratio of the cutout radius to the half length of the plate sides. For the case studied, diagrams of stresses are given for several points along the circumference of the cutout.

W. Wierzbicki, Poland

1630. **Sheremet'ev, M. P., Plane-stress condition of a plate with a reinforced circular hole** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **14**, 81–100, 1953.

First of all, boundary conditions are deduced for the plate with the hole reinforced by a thin ring with constant cross section. One of the principal axes of the ring cross section lies in the plane of the plate. The stress condition in the plate is plane. It is assumed that the reinforcing ring represents an elastic line submitted to flexure and to extension.

Here is discussed the case when the infinitely long plate with circular hole is submitted to extension. The small deformations of the circular ring, taking into account the compressibility of its axis, are solved by the load expressed by a Fourier series. The calculation of a copper plate with a circular opening reinforced by a copper ring is given.

Also discussed is the case of the anisotropic plate, when the isotropic ring is welded to the circumference of the circular opening.

W. Wierzbicki, Poland

1631. **Contri, L., Study of plates of linearly variable thickness** (in Italian), *Atti Ist. Veneto Sci. Lett. Arti. Cl. Sci. Mat. Nat.* **111**, 183–195, 1953.

Paper concerns the small transverse displacements of a rectangular plate of variable thickness. Two opposite edges are restricted to be simply supported, but the boundary conditions along the other two edges may be quite general. The thickness varies linearly across a section perpendicular to the simply supported edges and is constant across a section parallel to these edges. The fundamental differential equation admits of a relatively simple treatment when Poisson's ratio ν has the value 1/3, and this special case is discussed generally for various types of applied load, including that of uniform load. An iterative method of successive approximation is suggested to deal with the case $\nu \neq 1/3$.

H. G. Hopkins, England

1632. **Washizu, K., On the bending of orthogonally aeolotropic plates,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 157–162.

Solutions of the equations for the bending of orthogonal aeolotropic plates are expressed in terms of the stress functions associated with the plane stress of two-dimensional aeolotropic plates.

Elementary solutions of the Volterra type containing singular points at the origin are discussed. Relations between bending characteristics and the stress functions are established.

By means of a mapping function, the solution is indicated for an infinite plate with an elliptical hole subjected to uniform bending at infinity.

M. V. Barton, USA

1633. **Kempner, J., Remarks on Donnell's equations,** *J. appl. Mech.* **22**, 1, 117–118, Mar. 1955.

Flügge's set of differential equations of equilibrium for circular cylindrical shells is expressed in a form analogous to the Donnell equations. The results of solutions of the two sets of equations for a simply supported cylinder under a centrally applied, uniformly distributed radial line load over a generator segment, as well as under sinusoidally applied line loads, are in very good agreement for the particular geometry investigated.

From author's summary

1634. **Naghdi, P. M., and De Silva, C. N., On the deformation of elastic shells of revolution,** *Quart. appl. Math.* **12**, 4, 369–374, Jan. 1955.

The linear theory of rotationally symmetric deformations reduces, mathematically, to the study of two coupled second-order differential equations. For shells of constant thickness and constant meridian curvature (cylinder, cone, sphere, torus), the two equations can be reduced to a single second-order differential equation with complex coefficients [E. Meissner, *Phys. Zeit.* **14**, p. 343, 1913]. Using E. Reissner's formulation [AMR **3**, Rev. 229], authors show that a similar reduction to a single complex second-order differential equation is possible if the thickness varies in a special manner which depends on Poisson's ratio and on the shape of a meridian or generating curve.

R. A. Clark, USA

1635. **Ambartsumyan, S. A., On the construction of approximate theories of the computation of sloping cylindrical shells** (in Russian), *Prikl. Mat. Mekh.* **18**, 3, 303–312, May/June 1954.

Paper gives a systematic collection of all known approximate methods for solving the elasticity problem of sloping cylindrical shells. These methods are scattered throughout the literature which is listed at the end of the paper. The choice of a given method depends chiefly on the ratio of dimensions. The approximate methods are based on the following assumptions and simplifications: (a) that longitudinal bending moments are absent; (b) that deformations along a cylindrical element of the middle surface are absent; (c) that turning moments are absent; (d) that in the middle surface the torsional displacements are absent; (e) that bending moments in the plane of the circular cross section are absent; (f) that deformations along an arc of the middle surface are absent.

For a certain ratio of dimensions a certain combination of two or three of these assumptions is used and the differential equations simplify accordingly. The author discusses all possible cases, solves an example for a given external load and given supports, and also presents tables with numerical data for different ratios of dimensions.

T. Leser, USA

1636. **Srinivasan, P., Rotating disc with a stress-variation given by unit function,** *J. Indian Inst. Sci.* (*B*) **36**, 2, 88–94, Apr. 1954.

1637. Spampinato, A. B., Solution of the problem of translation shells (in Spanish), *Rev. Univ. nac. Eva Peron* (2) **5,** 205, 29–54, Mar. 1954.

The middle surface of translation shells is generated by translation of a vertical plane curve along another orthogonal vertical plane curve. These shells are supported along their edges by vertical structures not subjected to normal forces, thus creating only shearing reactions. Their great stiffness and the small stresses generated allow them to cover economically considerable surfaces without intermediate columns (over 31,000 m^2 according to the author).

Equilibrium and boundary conditions are expressed by systems of differential equations hardly integrable. By means of a convenient change of variables and introduction of a stress function similar to Airy function, problem may be reduced to the study of a membrane stretched and fixed along its boundary, obtained by projection of shell on a horizontal plane.

Author presents resolution of nonhomogeneous second-order, variable coefficients equation thus deduced, by means of Southwell relaxation method, emphasizing that he conceived this solution at the same time but independently of Flügge.

This method allows numerical tabulation and author gives tables of numerical values for shells with parabolic directrix and square plan. Also given is a practical example of its application.

F. Correia de Araújo, Portugal

1638. Carlson, W. B., and McKean, J. D., Cylindrical pressure vessels: Stress systems in plain cylindrical shells and in plain and pierced drumheads, *Inst. mech. Engrs.*, 17 pp., 1954.

Paper deals with three aspects of pressure-vessel stress analysis and design: (1) stresses in cylindrical shells resulting from out-of-roundness; (2) stresses in plain torispherical heads; (3) stresses in heads having flanged or reinforced manholes.

Under (1), it is shown that Haigh's analysis gives results in agreement with experiment, and that the standard of circularity demanded by American and British codes of practice precludes serious stress due to out-of-roundness.

Under (2), the influence of the ratios of depth and thickness of head to diameter on the stress-range ratio is examined, stress range being defined as the change in stress during the application of pressure and stress-range ratio as the ratio of the maximum range in head stress to that in circumferential cylinder stress. Calculated discontinuity stresses are compared with experimentally determined values, and there is shown to be reasonably good agreement. The effect of residual stress due to plastic strain caused by test loading is discussed, tentative recommendations as to working stresses are offered, and the ASME, BSI, and German code methods of thickness determination are compared.

Under (3), experimentally determined stress-range ratios for heads having manholes are presented and significant relationships are pointed out.

This paper should be of interest and value to engineers concerned with pressure-vessel design. It suggests several questions calling for further research, one being that of the plastic stress range necessary to produce failure after a limited number of cycles.

R. J. Roark, USA

1639. Müller, W., Theory of bending of the flat slab floor (Pilzdecke) supported on four rectangular faces (in German), *Ing.-Arch.* **22,** 163–170, 1954.

Paper deals with a rectangular slab supported on four rectangular faces. The supporting surfaces are symmetrical relative to the median lines of the slab; their sides are parallel with those of the slab. Uniformly distributed load p, normal to the middle surface of the slab, is assumed. Uniformly distributed support forces (reactions) q = const are supposed to arise on the supporting forces.

Paper is closely related to treatises of the author on similar subject published in AMR **7,** Rev. 2440 and in *Ing. Arch.*, 1954. Not median lines of the slab, but its two adjacent sides, are chosen for coordinate axes. Load p and deflection w of the slab are produced by summation of two simple and one double series. These series are summed up by formulas taken from the author's previous paper, or are transformed to rapidly converging simple series. In the course of calculation, the area of the slab is divided into different zones, and summation is executed separately in each zone.

Besides the general case, that of the slab supported on surfaces with infinitely small sides (point supports) is treated separately. For this case the formulas pass into those taken from a previous paper of the author. The case of the slab supported on two continuous surfaces (strips) of finite width is also dealt with.

Paper disregards the case of practical importance when deflection of the slab all over the supporting faces is $w = 0$.

Reading of the paper is rendered difficult by several typographical errors.

P. Csonka, Hungary

1640. Poplavskiĭ, R. P., Method for computation of plates and membranes (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **16,** 149–172, 1953.

Author investigates boundary-value problems for bending of plates which are controlled by the biharmonic partial differential equation, and for stretching of membranes controlled by the harmonic equation. The contours are elliptic, ring-shaped, semicircular, rectangular, triangular, and combinations of the foregoing. The loads are continuous and expressed by polynomials. The conventional solutions by separation of variables lead to very slowly converging series, therefore problems of this kind are often solved in terms of certain polynomials found by trial and error. This work is an attempt to find a general procedure for finding a polynomial part of the solution which for mathematical and physical reasons can be regarded as the main part of the solution. Numerical examples illustrate the theory and the results are compared with solutions by other investigators, giving a good agreement.

T. Leser, USA

1641. Grigolyuk, E. I., Strength and stability of cylindrical bimetallic shells (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **16,** 119–148, 1953.

Article treats the strength and stability of an axisymmetrical cylindrical bimetallic shell. The shell is considered thin and elastic. It is assumed that there is no pressure between the layers and no normal deformation takes place. Both shells of infinite and finite length are investigated. Examples of calculation of stresses and displacements are given. It is shown that a homogeneous shell is a special case of a bimetallic one.

From author's summary by M. Maletz, USA

1642. Iijima, H., On the strength of welded locomotive boiler, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 111–117.

Tests were made on a test boiler consisting of two courses—one riveted and one welded. A steam dome, riveted or welded, respectively, was attached to each course; the openings were reinforced as required by the ASME Boiler Code. Strains were measured at 135 gage lines to show the distribution of stress and radial deflections were measured with a dial indicator. The shell plate yielded at a pressure of approximately 36 kg/cm^2 whereas the maximum pressure, limited by leaking of the riveted reinforcing pad, was about 50 kg/cm^2. An analysis is made of the leakage pressure for the flanges of the steam domes.

Marshall Holt, USA

Buckling Problems

(See also Rev. 1888)

1643. **Franciosi, V., Buckling in the elasto-plastic range,** *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 531, 13 pp., Oct. 1954.

The buckling load of a simple column in the inelastic range is proved, by an original mathematical approach, to be the Engesser (tangent-modulus) load. The results agree with those of Duberg and Wilder [*NACA TN* 2267, 1951] and Pflüger [*Ing.-Arch.* **20,** no. 5, 1952].

F. R. Shanley, USA

1644. **Gatewood, B. E., Buckling loads for columns of variable cross section,** *J. aero. Sci.* **21,** 4, Apr. 1954.

This note presents curves for the buckling coefficient for all taper ratios and for any moment of inertia variation between constant and the sixth power.

From author's summary

1645. **Sanks, R. L., Reinforced concrete columns quickly designed by chart,** *Civ. Engng.*, *N. Y.* **24,** 9, 69–70, Sept. 1954.

Joints and Joining Methods

(See also Rev. 1681)

1646. **Nishihara, T., and Fujii, T., Stresses in bolt head,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 145–150.

Stress-concentration factors are calculated by analytical method as a case of two-dimensional stresses in a meridian plane. Bolt head and shank are separately calculated, and stress functions are chosen suitable to simplified boundary conditions. An example shows that the neglected stresses are small compared with those of the important part of the bolt. Results show values a little higher in comparison with those found photoelastically.

G. Sonntag, Germany

1647. **Nehl, F., and Rose, A., Application of time-temperature-transformation curves to special problems in the fabrication of high-duty welded structures** (in German), *Stahl u. Eisen* **74,** 17, 1054–1062, Aug. 1954.

1648. **Hartbower, C. E., Effect of reinforcement on performance of weldments,** *Welding J.* **33,** 3, 141s–146s, Mar. 1954.

Mild steel weldments joined with E6010 and E12016 electrodes have been subjected to balanced biaxial loading over a range of testing temperatures. The tendency to fracture was compared with and without weld reinforcement. In contradiction to the general belief that weld reinforcement is beneficial by virtue of the greater cross section provided, it was found that the tendency to produce brittle fractures was decidedly lessened when the welds were ground flush than when weld reinforcement was left intact. A rise in transition temperature of approximately 80 F resulted from the presence of reinforcement. Thus, removal of weld reinforcement appears desirable, at least in critical locations known to be subject to severe loading.

From author's summary

1649. **Möhler, K., Experiences and experiments with wooden joints and wood construction** (in German), *Schweiz. Arch.* **20,** 7, 224–236, July 1954.

1650. **Cowan, H. J., R. C. tanks with monolithic joints,** *Civ. Engng. Lond.* **49,** 575, 497–498, May 1954.

Structures

(See also Revs. 1587, 1623, 1637, 1639, 1645, 1684, 1870)

1651. **Harris, E. C., Elements of structural engineering,** New York, The Ronald Press Co., New York, viii + 505 pp. $7.

This elementary text is written primarily for students of electrical and mechanical engineering, etc., who do not intend to specialize in this subject. About half the book is devoted to theory and the remainder to a discussion of the design process for simple steel, reinforced-concrete, and timber structures. The aim is to bring the student to the point where he will be able to design simple supporting structures of the types he is likely to meet in the course of day-to-day work as an electrical or mechanical engineer. No attempt is made to give a thorough background, which is held to be necessary only for a specialist in the structural field.

Thus the book reflects one of the "great debates" of engineering education: Should a practical, though necessarily superficial knowledge of related specialties be given, or should teaching outside the student's field of specialty be restricted to general principles? Proponents of the first point of view argue that to teach general principles without teaching the student a practical skill represents effort that leaves the student still "up in the air," while proponents of the latter view argue that a well-trained engineer with a good grasp of principles can always pick up the details later and is in a much stronger position than one trained as a "handbook engineer."

In the opinion of this reviewer, the book in question can find its place only within the framework of the first-mentioned practical approach; as such it should prove a useful teaching book. In a syllabus reflecting the basic approach, the need for a book of this type would not arise because the students would in all probability be given a continuing materials and structures sequence which would take them through statically indeterminate and inelastic structures to a stage in analysis well beyond that presumed in this book.

The book is well set out and illustrated and many examples are given, some as facsimile work sheets. There are nearly 200 examples for assignment. In the chapters on steelwork design the text is intended to be read side by side with the AISC specification for structural steel for buildings; in the chapter on reinforced concrete the ACI code is to be used. Appendixes give a partial list of steel sections, information on loadings, details of riveted and welded joints, and design information for timber structures. The presentation is clear, on the whole, but there are a few weaknesses. When analyzing forces in simple frameworks (p. 39), the confusing term "condition" equation could be avoided by distinguishing between redundancy of support and internal redundancy. When riveted joints are discussed (p. 199), the reader is left with the impression that the design process for nonreversing loads envisages elastic conditions throughout and that the effects of stress concentration are merely "ignored." However, these and similar points do not detract seriously from the usefulness of the book for teaching on the lines envisaged.

R. M. Haythornthwaite, USA

1652. **Stüssi, F., Theory of structures. II** [**Baustatik**], Basel, Verlag Birkhäuser, 1954, 313 pp., 217 figs. SFr. 33.30.

This is a second volume of a sequence of three volumes dealing with structural theory. The first volume, reviewed previously [AMR **7,** Rev. 3539], introduced the theory of statically determinate structures; the present book extends the treatment to the more common cases of indeterminate structures, while, according to the author's preface, the last volume is expected to include the solution of problems of a special and less common nature. It is believed that the complete sequence will thus constitute

the nucleus of a reference library in which the structural engineer will find a discussion of most problems which he can reasonably expect to encounter in his practice.

The organization of the present volume follows closely that of other books on the same subject. In the first two chapters, author develops the fundamental principles on which the more detailed treatment of the following five chapters is based. The basic theorems of structural theory (virtual work, reciprocity, etc.) are stated and proved with a fair degree of rigor and are then employed to derive the standard mechanisms of the solution of redundant problems. Special emphasis is placed on the fact (too often overlooked in other textbooks) that all avenues of approach converge into two main arteries, of which one is based on the compatibility conditions in terms of equilibrated force systems, and the other on the equilibrium equations in terms of compatible displacements. Thus a structure of unusual clarity arises, which is not marred by the wealth of detail exposed in the following chapters. Following the European tradition, the solution of the resulting set of linear equations is discussed in great detail, with particular attention directed toward Gauss' method of elimination.

After the basis has thus been laid, chaps. 3 to 7 present a detailed discussion of the various common structural forms, such as girders and frames, arches, bents, suspension systems, and redundant trusses. While the treatment of the subject is conventional, its coverage is comprehensive beyond the usual scope. For example, the chapter on arches includes a brief but elegant discussion of the effect of the deformations on the equations of equilibrium and on the stability of arches. Similarly, the inclusion of Vierendeel truss analysis and a much more than cursory treatment of suspension systems enhances the reference value of the book.

On various occasions, author makes it clear to the reader that he disdains certain numerical methods which have found increasing acceptance here as well as, more recently, in Europe. Questioning the usefulness of iteration and relaxation schemes in connection with the equations of redundant structures in general, he singles out the well-known Cross process as a special target of criticism. Much of this is unjustified. For example, the author's claim that "conditions of symmetry cannot be utilized to simplify the computations" is patently incorrect. Similarly, for ordinary structural problems, convergence difficulties do not arise. Finally, reviewer feels that one of the major advantages of the Cross process, namely, the replacement of a purely mathematical procedure by one having obvious physical meaning, is too significant from the point of view of the practicing engineer to be dismissed lightly. In fact, it is probably this physical realism which has contributed more than any other single factor to the popularity of the Cross method.

Nevertheless, at a time when moment balancing is threatening to take the place of analytical skill, reviewer finds the author's reiteration of the value of the classical methods refreshing. This becomes evident if it is considered that for many classes of structures the Cross procedure is either disadvantageous or altogether inapplicable. Yet the technical literature of the past two decades is replete with attempts to introduce this technique, come what may, even in connection with problems in which superior classical solutions are available. The author is apparently attempting to counteract this trend. Similarly, he ignores certain attempts to interpret the basic structural equations through physical analogies (column analogy, etc.). On the other hand, reviewer feels that a discussion of the analysis of difference equations, such as are encountered in the form of the well-known three-moment equations, might have added to the reference value of the book.

It is inevitable that a volume of this size contain at least some ambiguities. For example, the statement (on p. 13) that for orthotropic materials the two moduli E_{xy} and E_{yx} "may be assumed approximately equal according to observations obtained thus far" seemed unclear to the reviewer. Other oversights, such as referring to a reciprocal matrix as a conjugate matrix (on p. 89), will undoubtedly be rectified in the next edition. More serious is the absence of an index and the paucity of bibliographical references. Printing and illustrations are clear and the general organization and appearance pleasing.

In summary, reviewer believes that this volume represents a distinct contribution to the literature on the subject and should find its way into many reference libraries of design engineers.

E. F. Masur, USA

1653. Smolira, M., Analysis of statically-indeterminate structures by the deformation method. Parts I, II, III, IV, V, *Concr. constr. Engng.* **49,** 7, 8, 9, 10, 11; 209–220, 251–260, 257–282, 315–321, 349–357, July, Aug., Sept., Oct., Nov. 1954.

Method is particularly applicable to curved members and Vierendeel trusses and involves writing sets of simultaneous equations involving deformations of the structure (angular rotations and joint deflections). Method is first outlined and then applied successively, with numerous worked examples, to continuous beams, portal frames, continuous frames with straight members, single-span frames with curved members, thin elastic rings, and continuous frames with curved members. Tied frames and the effects of temperature are also considered.

J. Heyman, England

1654. Beer, H., Composite structures (in German), *Öst. Bauzeitschr.* **9,** 6, 7, 8/9; 97–99, 120–127, 147–155, June, July, Aug./Sept. 1954.

Paper is an introduction to the study of composite structures. Theoretical and practical problem of bridges composed of concrete slabs on steel girders is solved. Influence of temperature differences, creep, and variation of elastic modulus with time is considered in connection with prestressing of the reinforced-concrete slabs.

Although paper does not present any new theory, it can be useful as an up-to-date compilation of research carried out in German-speaking countries during the past five years.

H. F. Long, Argentina

1655. Kamei, I., Wind pressure coefficient for structures in natural wind. (In the case of cylindrical and hexagonal towers), *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 443–446.

This short paper examines the effect of the turbulence and gustiness of the natural wind on the value of the coefficient of wind pressure on structures. A simple technique is described for measuring this pressure on real structures. Measurements made on a cylindrical and a hexagonal structure, situated in an urban area, are compared with the results of the corresponding experiments on models placed in wind tunnel. The results differ considerably and, in particular, the drag coefficient for cylinders is found appreciably lower for the natural wind than in wind tunnel, a conclusion which should have a practical incidence on the design of tubular steel structures.

Ch. Massonnet, Belgium

1656. Moorman, R. B. B., Continuous prestressing, *Proc. Amer. Soc. civ. Engrs.* **81,** Separ. no. 588, 21 pp., Jan. 1955.

Author discusses the influence of posttensioning on statically indeterminate structures, such as continuous beams, by introducing equivalent loads corresponding to the bending moments caused by an eccentric cable. Cables with parabolic curvature

are studied especially, and numerical examples are given together with a recommendation for analysis and design procedure.

C. J. Bernhardt, Norway

1657. Gebauer, F., Deformation work in reinforced-concrete beams (in German) *Beton u. Stahlbeton.* **50,** 1, 24–26, Jan. 1955.

1658. Investigation of the suitability of Prepakt concrete for mass and reinforced concrete structures; Appendix A, Properties of Alfesil, and tests of permeability and resistance to natural weathering of Prepakt concrete; and Appendix B, Use of Prepakt in field operations, *Wwys. Exp. Sta. tech. Memo.* no. 6-330, Aug. 1954.

1659. Kranz, Drop hammer tests with three oleo strut models and three different shock strut oils at low temperatures, *NACA TM* 1372, 55 pp., July 1954. (Translation from *Zentrale für wissenschaftliches Berichtswesen der Luftfahrtforschung, Untersuch. u. Mitt.* 564, Jan. 1939.

Drop hammer tests with different shock strut models and shock strut oils were performed at temperatures ranging to −40 C. The various shock strut models do not differ essentially regarding their springing and damping properties at low temperatures; however, the influence of the different shock strut oils on the springing properties at low temperatures varies greatly.

From author's summary

1660. Sambito, G., Calculation of prestressed reinforced-concrete silo (in Italian), *G. Gen. civ.* **92,** 1, 22–28, Jan. 1954.

General theory of prestressed concrete cylindrical shells and its use in silo design is presented in some detail. Effects of concrete shrinkage and plastic flow are considered. Since pretensioning is introduced after concrete hardens, evaluation of these effects shows them to be harmful; influence of wire creep is neglected.

This method was used to design 10 cement silos—11.40-m diameter, 22.40-m height—recently built in Naples. Calculation of these silos is given as an example, and mechanical process of placing and prestressing spiral reinforcement according to Prebeton method (Italian employment of Swiss patent Stahlton) is described. No vertical prestressing was made, permanent vertical compression of concrete being supposed to be naturally derived from friction between stored cement and walls.

F. Correia de Araújo, Portugal

1661. Bleifuss, D. J., and Hawke, J. P., Rock-fill dam design and construction problems, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 514, 23 pp., Oct. 1954.

1662. Link, H., Design of steel or concrete well covers (in German), *Tech. Mitt. Krupp* **12,** 6, 136–143, Sept. 1954.

1663. Corbetta, G., Bars of equal strength in bending in airplane structures (in Italian), *Ingegnere* **28,** 8, 867–874, Aug. 1954.

The principle of bars of equal strength and fundamentals of shell structures are first discussed. Author shows that, in some instances (conical shells), the latter can be formed to satisfy the condition of equal strength. A better proportion between structure cross section and stress, and hence improved material usage, is thereby obtained. The discussion is summed up in and clarified by a practical example.

From English summary

1664. Ashburn, A., Production problems on supersonic planes, *Amer. Machinist,* Spec. Rep. no. 368, p. 129, July 1954.

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1559, 1611, 1643)

1665. Hodge, P. G., Jr., Rigid-plastic analysis of symmetrically loaded cylindrical shells, *J. appl. Mech.* **21,** 4, 336–342, Dec. 1954.

E. T. Onat (see forthcoming paper in *Quart. appl. Math.*) has discussed the general problem of the collapse of cylindrical shells of rigid-plastic Tresca material under conditions of rotational symmetry. Within the framework of conventional shell theory, the yield surface is defined in a three-dimensional space. In this space the axial and meridional stress resultants and the axial bending moment, all made suitably nondimensional, are taken as rectangular Cartesian coordinates. The yield surface is closed, convex, and singular. It is made up of parts of certain quadric surfaces including planes, and, accordingly, in general there is some complexity in the yield function and flow rule appropriate to any particular plastic regime.

The present writer derives, through the consideration of an ideal sandwich shell, a dodecahedron as an approximation to the true yield surface. This linearized yield surface has the obvious advantage of simplifying both the yield function and the flow rule for the various plastic regimes. A similar procedure was adopted by D. C. Drucker [Proc. 1st Mid-West. Conf. Solid Mech. (Urbana, 1954), pp. 158–163] for the same problem in the absence of axial force. It is readily appreciated that the solution of important problems is made much simpler in this way with but little resulting loss in accuracy. The present analysis is applied to the problem of a shell subject to uniform external pressure, the shell either being closed by rigid bulkheads or open and supported by rigid rings at each end. In the former case the bulkheads are also subjected to the same pressure. The author, correctly, cautions against the application of the numerical results in any situation likely to involve the occurrence of instability.

It may be noted that E. T. Onat and W. Prager [*Proc. K. Ned. Akad. Wet.* (*B*) **57,** 534–548, 1954] have recently extended limit analysis to shells of revolution. A similar linearization of the (four-dimensional) yield surface would again simplify the solution of problems.

H. G. Hopkins, England

1666. Ibrahim, A. A. K., Navier-Stokes' equations for non-Newtonian liquids, *J. chem. Phys.* **22,** 7, p. 1274, July 1954.

1667. Green, A. P., Hodographs in problems of plane plastic stress, *J. Mech. Phys. Solids* **2,** 4, p. 296, June 1954.

Author has recently shown that, for an ideal plastic-rigid body undergoing plane plastic deformation, there is a certain geometrical similarity between the slip-line field in the physical plane and the corresponding network of lines in the hodograph of the velocity distribution (Green, 1951, 1954). The aim of this brief note is to show that this result can be extended to problems of plane plastic stress.

From author's summary

1668. Ross, A. D., Experiments on the creep of concrete under two-dimensional stressing, *Mag. Concr. Res.* no. 16, 3–10, June 1954.

The tests were designed to investigate the creep of concrete specimens under (a) two compressive principal stresses, and (b) one compressive and one tensile principal stress. The equipment for producing the stresses and the gages for measuring the strains are described. Results are presented which suggest that creeps develop in the principal directions with magnitudes generally of the same order as the corresponding creeps under simple stress. Poisson's ratio for creep strains appears to be negligible.

From author's summary

1669. Meixner, J., Thermodynamic expansion of the theory of aftereffects (in German), *Z. Phys.* **139,** 30–43, 1954.

In AMR **7,** Rev. 3335, author formulated a general theory of aftereffects connecting the thermodynamical pressure p with the specific volume v. This is now expanded by referring to the stress σ and strain ϵ and including temperature among the stress and entropy among the strain components. The tensors of stress and strain, which thus each possess 7 components, are considered as vectors of 7 dimensions connected by $\sigma_i = \bar{c}_{ik}\epsilon^k$, with $\bar{c}_{ik}$ the thermoelastic matrix for uninhibited thermodynamical equilibrium. If ϵ is a function of t, a generalization of Boltzmann's one-dimensional nonthermodynamic equation of elastic aftereffects results

$$\sigma_i(t) = c_{ik}\epsilon^k(t) - {}_0\int^{\infty} C_{ik}(u)\epsilon^k(t - u)du$$

with $C_{ik}(u)$ as the matrix of aftereffects. The lower limit of the integral is taken as zero to provide that only strains existing *before* t influence the stress. For inhibited aftereffects, $\sigma_i(t) = c_{ik}\epsilon^k(t)$.

The theory is developed in more detail for isotropic viscoelastic materials and isentropic changes. The resulting stress-strain relations contain an adiabatic static bulk $K(0)$ and shear modulus $G(0)$ and frequency-dependent bulk K and shear moduli G, as well as volume ξ and shear viscosities η. The important result is obtained that Lamé's constant $\lambda = K - (2/3)G$ has no physical significance. For relaxation phenomena, $C_{ik}(u) = (q_i q_k/\tau)e^{-u/\tau}$ where τ is a "relaxation" time. For volume strains, the following dynamical equation is postulated

$$\sigma_m + \tau_\epsilon \dot{\sigma}_m = K(0)\,(\epsilon_v + \tau_\sigma \dot{\epsilon}_v)$$

where σ_m is the mean normal stress, ϵ_v the volume strain, τ_σ and τ_ϵ relaxation times at constant stress and constant strain, respectively; the paradoxical result is obtained that $\tau_\sigma \geq \tau_\epsilon$.

M. Reiner, Israel

1670. Olszak, W., and Litwiniszyn, J., Non-linear liquid flow as a rheological model, *Bull. Acad. Polonaise Sci.* **2,** 2, 69–73, 1954.

The dashpot of the usual rheological model is replaced by two interconnected vessels, one cylindrical closed by a piston, the other of varying shape. By permitting the liquid to condense or to evaporate, by assuming friction between piston and wall, and by replacing the viscous or nonviscous liquid by a gas, the model is made to represent a diversity of rheological behavior.

M. Reiner, Israel

1671. Thomsen, E. G., Yang, C. T., and Bierbower, J. B., An experimental investigation of the mechanics of plastic deformation of metals, *Univ. Calif. Publ. Engng.* **5,** 4, 89–144, 1954.

Here is an excellent investigation on the stress distribution in the inverted extrusion process using commercially pure lead at atmospheric temperature. The three parts of this pamphlet discuss: (1) A technique for visualizing plastic flow of a metal by determining the magnitude and direction of particle velocity for a three-dimensional forming operation; (2) an analysis of plastic strain by determining experimentally the magnitude and direction of particle velocities which are used in calculations of infinitesimal strain and strain rates for zones in steady motion; (3) a graphical determination of the plastic stresses which is called visioplasticity. One recognizes immediately the similarity of the photoelastic method for elastic stresses to this method for plastic stress evaluation, namely, graphical integration.

A grid line system enabled one to see the plastic flow on the meridian plane of the axially symmetrical billet. This method has been used by several investigators, but the new technique is to observe many incremental deformation extrusion steps (which varied from 0.01 to 0.10 in.) of selected intersection of grid lines. Thus, infinitesimal strain and strain rates were determined. The many photographs show intermittent stages of extrusion. It was found that magnitude and direction of particle velocity within the billet appear to be the same for a stepwise and a continuous extrusion process.

In the analysis of strain and strain rates, it was found that the magnitude of the maximum infinitesimal shear strain and effective strain reached a maximum value at the die edge when lead was extruded in the inverted process. Maximum shear strains change sign and hence direction in regions bounded by the cylinder wall and die plate and in the central region at the orifice.

Graphical determination of the stresses was made under the following assumptions: (a) Levy-Mises relations or the plasticity equations of stress-strain hold; (b) there are no inertial effects so that static equilibrium conditions are applied; (c) metal is continuous, isotropic; (d) plastic rates are available.

Although the method is a bit complicated, there is agreement with Lee's solution in the trend of the axial compression stress distribution. Axial stress at center line is not zero as assumed in the theoretical solution. Predicted and measured pressures on the cylinder wall are in good agreement.

H. Majors, Jr., USA

1672. Levi, F., Plastic readjustment at the boundary of surfaces of revolution (in French), *Publ. int. Assn. Bridge struct. Engng.* **13,** 221–238, 1953.

The structure considered is a circular cylindrical tank standing vertically and partially filled, whose sides are rigidly fixed at the root (i.e., at the bottom of the tank). An elastic-plastic relation between the bending moment and the curvature is assumed, with a linear work-hardening law. The governing equations of the problem, and the assumptions underlying them, are set up with great care. The solution is presented analytically at first, then a numerical example is worked out in detail. Curves of bending moment and of deflection against height are presented. It is found that plastic regions arise close to the bottom of the tank, which have the effect of decreasing substantially the root moment. Generalizations to other structures are indicated.

B. A. Boley, USA

1673. Stüssi, F., Contribution to the theory of plasticity (in German), *Publ. int. Assn. Bridge struct. Engng.* **13,** 12 pp., 1953.

Author develops a theory for isotropic materials based on the assumption that the principal strains in a triaxial state of stress are linear combinations of the principal strains in three uniaxial states of stress with the same equivalent stress, defined by $\sigma_g^2 = \sigma_1^2 + \sigma_2^2 + \sigma_3^2 - \sigma_1\sigma_2 - \sigma_2\sigma_3 - \sigma_3\sigma_1$. Denoting the principal strains in a state of stress $\sigma_1 = \sigma_g$, $\sigma_2 = \sigma_3 = 0$ by ϵ_{11}, ϵ_{21}, and ϵ_{31}, etc., and putting $\sigma_1/\sigma_g = \mu_1$, etc., the hypothesis is expressed by $\epsilon_1 = \mu_1\epsilon_{11} + \mu_2\epsilon_{21} + \mu_3\epsilon_{31}$, etc. The theory is compared with experiments by J. Marin [AMR **3,** Rev. 2332] and by the author; the agreement is quite satisfactory. Reviewer notes that theory seems restricted to uniform loading, i.e., constant directions of principal axes and constant ratio $\sigma_1:\sigma_2:\sigma_3$.

W. T. Koiter, Holland

1674. Inoue, N., Statically determinate solutions of elastic-plastic problems, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 245–250.

Author claims to have solved the elastic-plastic plane strain problem for an infinite half plane under a uniform normal load over one half of the straight boundary. The utility of this solution appears doubtful to the reviewer. The validity of the solution depends on the occurrence of stresses at an infinite distance

which are finite and have a particular distribution. It appears difficult to conceive of circumstances in which these stresses will occur. W. M. Shepherd, England

1675. **Knowles, J. K., and Dietz, A. G. H., Viscoelasticity of polymethyl methacrylate—an experimental and analytical study,** *Trans. ASME* **77,** 2, 177–184, Feb. 1955.

See AMR **7,** Rev. 1827.

1676. **Bailey, R. W., A critical examination of procedures used in Britain and the United States to determine creep stresses for the design of power plant for long life at high temperatures,** *J. appl. Mech.* **21,** 4, 309–322, Dec. 1954.

See AMR **7,** Rev. 2155.

Failure, Mechanics of Solid State

1677. **Huber, A. W., and Beedle, L. S., Residual stress and the compressive strength of steel,** *Welding J.* **33,** 12, 589s-614s, Dec. 1954.

Purpose of the investigation was to determine the effect of residual stresses and strains set up during cooling on the strength of structural steel compression members. In addition to experimental results, two analytical methods on the influence of residual stresses and strains are presented. The first of these is based on an assumed residual-stress distribution, while the second method is based essentially on the measured distribution.

The test material was an ASTM Grade A-7 steel rolled to 8WF31 shape. In addition to compression tests of seven axially loaded section members removed from full columns, tension and compression tests were made on small samples. These samples were removed from various locations in the web and flange sections. Six sets of residual-strain measurements and six cross-section tests on section members were made. Tests on hot-rolled and annealed material were included.

Residual stresses in large section members were found to lower column strength (proportional limit). The residual stresses in the flanges are of particular importance. Generally, in the web the residual stresses are tensile with a maximum of +16,000 psi, and in the flanges the maximum stress varied from +11,000 psi at the center to −17,500 psi at the edges. All residual stresses and strains can be eliminated by annealing.

No change is found in the magnitude or distribution of the residual stresses in the center sections of a beam which is removed from the full member if the length removed is about three times the depth. Thus results on center section members approximate those on full members. Satisfactory values of E and yield stress can be determined from tests on section members. It is found, however, that for both annealed and hot-rolled material the lower yield stress level of section members is as much as 10% lower than for small samples. Authors believe this difference to be due to a size effect. Reviewer believes the differences in size and shape have an effect on strain distribution or state of stress.

F. Garofalo, USA

1678. **Miles, J. W., On structural fatigue under random loading,** *J. aero. Sci.* **21,** 11, 753–762, Nov. 1954.

Problem of determining stresses resulting from random loading is discussed. The method of using the power spectral density of the input force in determining the response of a resonant panel is presented. The probable fatigue damage resulting from this response is treated by Miner's cumulative damage theory. Author's method is applied to the specific problem of jet buffeting of a panel. S. Levy, USA

1679. **Freudenthal, A. M., Safety and the probability of structural failure,** *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 468, 46 pp., Aug. 1954.

Author discusses structural design from point of view that it must of necessity be based upon predictions of loads and performance of materials. Many loads are subject to random variations, and it is generally recognized that the same can be said for mechanical properties of materials. Predictions of both must, therefore, involve concept of probability. Rational design should include, in addition to analysis of stresses, analysis of loads and materials, with accompanying probability considerations. Such a rational design method is presented by author.

Load analysis involves study of random variations of standard load intensity. Types of random variations which might be used are discussed. Since failure will be associated only with high loads of small probability of occurrence and past observations may include only lower loads of larger probability, it becomes necessary to extrapolate to range of small probability. In order to be suitable for such extrapolation, distribution functions should be based on rational assumptions. Logarithmic-normal and extreme value distributions are suggested as good possibilities.

Following load analysis, analysis of the structure may be either elastic or plastic depending on whether limiting condition is unserviceability or failure. Analysis is completed by taking into account random variation of mechanical properties of materials to be used. Again extrapolation must be made from observed values (high probability) to values associated with unserviceability or failure (low probability). Considerable information is now available on distribution functions for mechanical properties. As in case of load variations, logarithmic-normal and extreme value distributions are considered most suitable. Combined with elastic stress analysis or inelastic analysis these considerations lead to a distribution function for applied loads that will cause unserviceability or failure of the structure. Using distribution function for expected intensity of applied loads, the probabilities of failure may now be determined.

Final decision on optimum design may be based upon either safety or economics. Conventional safety factors are replaced by factors reflecting probability of failure, which, however small, must be recognized to exist in any structure. Hence design may be based upon specified acceptable probability of failure. If decision is based upon economics it represents balance between cost of increasing strength and cost of failure.

Reviewer feels that author has made an important contribution to field of structures, tying in with advances in field of mechanical properties. C. W. Richards, USA

1680. **Will, V. G., Failures of crane hooks and ladle hangers, and measures to be taken for their prevention** (in German), *Stahl u. Eisen* **74,** 17, 1062–1069, Aug. 1954.

1681. **Freudenthal, A. M., and Heller, R. A., Effect of thermal activation on fatigue life of butt welds,** *Welding J.* **33,** 7, 327s-338s, July 1954.

A study was made of the effect of rest periods at moderately elevated temperatures on the fatigue life of submerged-arc butt-welded specimens of A-285 steel. Mean *S-N* diagrams and the statistical scatter were observed by testing multiple specimens at eight stress levels. Groups of specimens were also subjected to various sequences of overstressing, both with and without thermal activation following each overstress history. It was felt that rest periods at elevated temperatures might relieve microresidual stress and prolong fatigue life, particularly after overstressing or in weld-affected zones. In general, specimens with the critical section at the weld center had longer fatigue life than nonwelded

specimens but exhibited somewhat greater scatter. Thermal activation following overstress was not significantly beneficial and, for high overstress levels, apparently reduced the fatigue life of metal in weld-affected zones. Data from about 800 specimens are presented in charts showing frequency of survival under the various conditions of test and clearly indicate the statistical nature of the problem. T. J. Dolan, USA

1682. Moszynski, W., Calculation of fatigue life of machine elements by aid of probability calculations (in German), *Maschinenbau-Technik* **3**, **7**, 344–353, July 1954. [Originally (in Polish) *Przeglad Mechaniczny* **2**, 271–274, 325–331, 1953.]

The safety factor of a machine element under static condition can be calculated by probability calculations, assuming as criterion the simultaneous occurrence of a number of *independent* chance variables. Strength properties (chance variables) appear to obey the log-normal distribution. The endurance limit is assumed to follow the same distribution. However, the assumption of *independence* of chance variables does not hold for fatigue application; e.g., geometry (dimension, size, notch) will affect strength variables through stress gradient variation. The same is true for surface condition and environment. This paper attempts to account for the most important interactions of chance variables of a machine element under cylic load condition, illustrating the method by a numerical example.

F. Forscher, USA

1683. Schallamach, A., On the abrasion of rubber, *Proc. phys. Soc. Lond.* (*B*) **67**, 420B, part 12, 883–891, 2 plates, Dec. 1954.

Theoretical results on the abrasion of rubber have been deduced from a few simple assumptions concerning the initiation of the surface damage. The abrasion is proportional to the normal load, independent of the particle size of the abrasive if the particles are polyhedral, and proportional to their mean radius of curvature if they can be approximated to hemispheres. The spacing of the abrasion pattern is proportional to the cube root of the normal load, proportional to the two-thirds power of the particle size on an abrasive with polyhedral particles, and directly proportional to the particle size on an abrasive with hemispherical particles. These predictions have been reasonably well confirmed by experiment. From author's summary

1684. Boyd, G. M., Brittle fracture problems in steel construction, *Struct. Engr.* **33**, 1, 11–19, Jan. 1955.

Material Test Techniques

(See Rev. 1688)

Mechanical Properties of Specific Materials

(See also Revs. 1563, 1645, 1649, 1668, 1676, 1677, 1683, 1693, 1700, 1814)

1685. Nakagawa, Y., and Okuda, S., On Poisson's ratio of cast iron (in Japanese), *Trans. Japan Soc. mech. Engrs.* **20**, 91, 125–129, Mar. 1953.

Poisson's ratio can be measured by the analysis of Newton's optical interference pattern, but for cast iron it is not always easy to make the polished surface of the specimen sufficiently flat to apply the method directly. In order to make the method applicable to the case where a slight convexity exists on the surface, authors improve the method, measuring translations of interference fringes due to variation of load and calculating the changes of convexity, and obtain a more accurate value of Poisson's ratio. As a result, they confirm experimentally that Poisson's ratio of cast iron varies according to internal stress, which is also the result of authors' theory for nonlinear elasticity.

T. Udoguchi, Japan

1686. Bailey, S. B., Nodular cast iron, *Proc. Instn. mech. Engrs.* 168, 24, 643–657, 1954.

1687. Willmore, T. A., Degenkolb, R. S., Herron, R. H., and Allen, A. W., Application of sonic moduli of elasticity and rigidity to testing of heavy refractories, *J. Amer. ceram. Soc.* 37, 10, 445–457, Oct. 1954.

The application of ASTM C 215-51 T (Tentative Method of Test for Fundamental Transverse Frequency of Concrete Specimens for Calculating Young's Modulus of Elasticity) to the nondestructive testing of 1 × 1 × 7-in. laboratory fire-clay specimens and standard 9-in. fire-clay and high-alumina refractory brick is reviewed. Both room-temperature measurements and hot sonic modulus of elasticity measurements to 1700 F are analyzed. Sonic moduli of elasticity and rigidity are compared with modulus of rupture by a theory of measurements and statistical analysis. . . .If Poisson's ratio is assumed to be zero rather than the conventional one sixth, ratios of sonic modulus of elasticity to rigidity are shown to approximate the theoretical ratio more closely. Effects of nonuniform density to displace normal nodes are illustrated. Hot sonic modulus of elasticity is shown to reflect changes due to crystallographic inversions, deterioration of chemical bond in unfired brick, and development of sintered bond in unfired brick.

From authors' summary by E. A. Davis, USA

1688. Chakravarty, A. C., Measurement of hardness of textile fibres. Part I, *J. Text. Inst. Trans.* **45**, 10, T723-T729, Oct. 1954.

Paper describes an instrument and method for studying the elastic response of three varieties of jute fibers from each of the species *Corchorus capsularis* and *Corchorus olitorius* when stress is applied in the form of a normal compression on the surface of the fiber—this elastic quality is defined as "hardness."

From author's summary

1689. Wood, C., Dynamic friction of viscose fibres and relative humidity, *J. Text. Inst. Trans.* **45**, 10, T794–T802, Oct. 1954.

The apparatus previously used in a fivefold factorial analysis is developed to investigate the relation between the frictional force necessary to withdraw a single fiber from a bundle held in a rectangular channel and the relative humidity.

A humidifying system is designed to condition air at the desired relative humidity. A conditioning cabinet is described which is designed to enclose the apparatus and to permit manipulation of the fibers and determination of the relative humidity without disturbance of the equilibrium.

The relation between frictional force and relative humidity is determined. From author's summary

1690. Howell, H. G., The friction of a fibre round a cylinder and its dependence upon cylinder radius, *J. Text. Inst. Trans.* **45**, 8, T575–T579, Aug. 1954.

Paper describes measurements of the friction of a fiber (nylon) against a cylinder of dissimilar material [(a) Perspex, (b) glass] and discusses the effect of a change in cylinder radius. Results were reproducible only when the cylinder surface had been specially cleaned. From author's summary

1691. **Meyer, S., Force measurements with vibrating systems** (in German), *Faserforsch. u. Textiltech.* **5**, 7, 302–308, July 1954.

Experience shows that the dynamometers commonly used for measuring the strength of yarns give, when the specimens are broken in a short time, greater values than those observed when the specimens are broken in a long time. Author examines if these results, instead of being explained by the properties of the material, are not the consequence of the behavior of the apparatus carrying masses capable of vibration. The dynamic equilibrium of such an apparatus is studied on the hypothesis that no friction occurs and on the hypothesis that different damping devices, including the elasticity of the specimen, must be taken into account. (Equation 8 and the next one are to be corrected for printing faults.) Graphs for different materials and different dynamometers, giving the observed erroneous elongations in function of the pendulum velocity, are in good agreement with the graphs of the calculated values. Author shows that it is possible to get exact results with friction devices. He proposes a practical method permitting determination, for pendulum dynamometers, of the velocity at which a test must be carried out on a specimen when breaking strength is approximately known. D. De Meulemeester, Belgium

1692. **Wood, G. C., The relaxation of stretched animal fibres II. The relaxation of human hair,** *J. Text. Inst. Trans.* 45, 6, 462–471, June 1954.

Relaxation curves of human hair stretched 10–50% in aqueous media have been determined. From author's summary

Mechanics of Forming and Cutting

(See also Rev. 1671)

©1693. **Machu, W., Surface treatment of iron and nonferrous metals (Degreasing, cleaning, polishing. . . . .etc) [Oberflächenvorbehandlung von Eisen- und Nichteisenmetallen (Entfettung, Reinigung, Beizen, Brennen, Schleifen, Putzen, Polieren usw.)],** Leipzig, Akademische Verlagsgesellschaft Geest & Portig K.-G., 1954, xx + 801 pp., 371 figs. DM 49.

Book is an encyclopedic treatise on various surface finish treatments as applied to ferrous and nonferrous metals and alloys. It seems to be very useful for one interested in securing various finishes of metallic surfaces (as it takes place, e.g., in construction of different machines and equipment).

There are eight parts discussing, successively, bath degreasing, mechanical washing and cleaning, acid decapping (separately of ferrous and various nonferrous metals and alloys), grinding, polishing, and bath-cleaning methods and installations.

Although the trend of the book is to give a rather general idea of a large number of problems, a reader who does not find enough data concerning his particular problem is guided in selection of more detailed literature by a very large bibliographical index, comprising 1705 (!) references. Thanks to the name and subject indexes, the reader finds at once the necessary description. The bibliographical references are well done and, although based chiefly on German sources, include English and Russian publications of very recent date. A. Niedzwiedzki, USA

1694. **Itokawa, H., and Ono, S., An ink-writing profilerecorder by ultra-sonic wave,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 533–540.

Design and performance data are presented for proposed surface roughness gage. Stylus tracing over rough surface varies slight gap between flapper and open end of side branch of tube carrying sound waves. Resulting variation in terminal impedance of side branch varies amount of sound energy transmitted through main tube. Sound at 10 kc is funneled into 5-mm-ID tube and picked up by microphone in reversed funnel at other end. Side branch is 11 mm long. Author claims amplification of 10,000 is possible. Production models are to be built. Reviewer feels this is doing it the hard way. W. W. Soroka, USA

1695. **Lindbeck, B., and Mannheimer, A., Measurement of surface roughness** (in Swedish), *Tekn. Tidskr.* **83**, 35, 716–720, Sept. 1953.

1696. **Ling, F. F., and Saibel, E., Interaction of friction and temperature at the chip-tool interface in metal machining,** ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-2, 5 pp.

Main purpose of this paper is to explore the possibilities of expressing both chip friction and cutting temperature in terms of independent variables of the cutting process. Empirical relation between friction and temperature, based on data in the literature, is introduced and an approximate analysis made of the chip-tool interface temperature in terms of this friction-temperature relation. This is carried out in similar manner to published cutting temperature analyses, except for introduction of friction-temperature characteristics. Results are given in expressions for both chip friction and cutting temperature which, with some approximation, are in terms of cutting velocity, physical properties of the material cut, and constants obtained from data in the literature. Reader is warned against numerous typographical errors appearing in preprint of paper. M. E. Merchant, USA

1697. **Shaw, M. C., and Finnie, I., The shear stress in metal cutting,** *Trans. ASME* **77**, 2, 115–123, Feb. 1955.

See AMR **7**, Rev. 3243.

1698. **Oxford, C. J., Jr., On the drilling of metals—1. Basic mechanics of the process,** *Trans. ASME* **77**, 2, 103–111, Feb. 1955.

See AMR **7**, Rev. 2894.

1699. **Neppiras, E. A., Machining by high frequency vibration techniques,** *Research, Lond.* **8**, 1, 29–34, Jan. 1955.

1700. **Majors, H., Jr., Effect of sequence on the coefficient of friction in cold-drawing low-carbon steel and 2S-O aluminum rods—Part III,** ASME Ann. Meet., New York, N. Y., Dec. 1954. Pap. 54—A-114, 13 pp.

Hydraulics; Cavitation; Transport

(See also Revs. 1568, 1661, 1670, 1712, 1762, 1823, 1871)

©1701. **McNeil, I., Hydraulic operation and control of machines,** London, Thames & Hudson, Ltd., 1954, xi + 324 pp. 35s.

In hydraulics, one of the most ancient of sciences, there has been a notable lack of comprehensive work dealing exclusively with one of its more modern phases—its application to industrial machinery. To those presently concerned with such application, this book should be of considerable assistance in filling this void.

While the scope of the subject is almost as wide as engineering itself, the author has so organized and restricted his material as

to include only the prime character of machine hydraulics. The essential theoretical concepts of fluid mechanics and hydraulic pressure are reviewed, followed by descriptions in summary fashion of a wide variety of hydraulic units and the components necessary to their operation. The volume contains many examples from the machine tool, press, mining, agricultural, marine, and aeronautical fields. Both British and American applications are included.

Apparently the book was not written to constitute a detailed aid to specific design, and some of the descriptions seem too brief to be entirely clear. An instance would seem to be found in the torque converter description or in the fact that no connection is made in the text to the letters in the diagram of Fig. 100, concerned with the Denny-Brown ship stabilizer.

Certainly a much better over-all appreciation of hydraulic principles and their application to the particular subject of industrial machinery should be derived from this treatment by Mr. McNeil.

A generous bibliography is appended. J. L. Martin, USA

1702. **Frazer, W., Hydraulic jump in prismatic channels,** *Engineering* **179,** 4642, 46–47, Jan. 1955.

1703. **Kherkheulidze, I. I., Determination of maximum discharge and solid runoff in torrents** (in Russian), *Gidrotekh. i Melior.* no. 4, 43–50, Apr. 1954.

Maximum discharge is determined by unit graph method. Solid discharge is computed as percentage to the liquid flow, estimating the concentration of transported material. This concentration varies with intensity of runoff, longitudinal slope, and size of drainage area. Several empirical formulas are offered and examples of computation included.

S. Kolupaila, USA

1704. **Romeijn, H. J., Irrigation and draining through navigation canals** (in Dutch), *Ingenieur* 66, 16, B.45–B. 46, Apr. 1954.

1705. **Anufriev, V. E., Siphon-spillway for stilling the tailrace flow** (in Russian), *Gidrotekh. Stroit.* **23,** 1, 39–41, Jan. 1954.

A siphon with adverse outlet is proposed to produce opposite flow in the tailrace of a spillway, or of a usual automatic siphon, for efficient dissipation of energy instead of stilling pools or baffles. S. Kolupaila, USA

1706. **Kokaia, N. V., Hydraulic characteristics of conical valves** (in Russian), *Gidrotekh. Stroit.* **23,** 4, 26–28, Apr. 1954.

An outlet valve with a permanent cone and sliding sleeve is less complicated than needle valve and is adopted in Russia. Investigation shows high efficiency of this valve. Discharge coefficient reaches 0.817 at 85.4% opening and is independent of pressure. S. Kolupaila, USA

1707. **Khovanskiĭ, G. S., Transparent nomogram for design of pipelines** (in Russian), *Gidrotekh. Stroit.* **23,** 3, p. 48, Mar. 1954.

Sliding scale for direct reading on the grid, based on formula by Pavlovskiĭ in its complete form. Convenient for usual computations. S. Kolupaila, USA

1708. **Nordström, H. F., Edstrand, H., and Lindgren, H., On propeller scale effects,** *Medd. SkeppsProvAnst. Göteborg* no. 28, 26 pp., 1954.

Authors give results of experiments on eight model propellers (250 to 300-mm diam) aimed at determining the influence of scale on the results of open water propeller tests and to establishing the minimum Reynolds number at which reliable results should be expected. Tests have been carried out upon recommendation of the Sixth International Conference of Ship Tank Superintendents (now International Towing Tank Conference). Report also includes results of tests on single propellers to determine effects of turbulence stimulation and surface roughness. Work, reported as propeller characteristics plots (torque and thrust coefficients and efficiency against advance coefficient), indicates that minimum Reynolds number (based on section at 0.7 radius) depends inversely on pitch ratio. For $P/D = 0.9$, $Re_{min} = 2.4 \times 10^5$. Tests on turbulence stimulation are rather inconclusive. Tests on roughness show marked dependency of characteristics on grain size of roughness (alundum grinding). Analysis of experiments indicates that all are affected by laminar flow even at the highest Reynolds number (7×10^6). This is remarkable in view of absence of scale effect above minimum Reynolds number. M. St. Denis, USA

1709. **Kamimoto, G., and Matsuoka, Y., Flow past a circular cylinder involving cavitation** (in Japanese), *Trans. Japan Soc. Mech. Engrs.* **19,** 85, 32–37, 1953.

Pressure-distribution measurement was made on a circular cylinder of 25-mm diam placed in a water channel of section 104 mm $\times$ 52 mm. Range of Reynolds number based on cylinder diameter was from 8×10^4 to 2×10^5 and that of cavitation number $k_d = (p_0 - p_s)/q_0$ was from 0.98 to 3.35, where p_s is saturated vapor pressure, and p_0 and q_0 are static and dynamic pressures of undisturbed stream, respectively. It was found that, at small values of k_d, cavitation occurs only over a localized region of low pressure, but when k_d exceeds a certain critical value, flow changes rather abruptly, cavitation extending right up to the rear end of the cylinder. Critical value of k_d seems to be reduced if the free-stream turbulence is increased by introducing a square-mesh grid.

I. Tani, Japan

1710. **Ananian, A. K., Equations of turbulent flow at the bend of a water duct** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **93,** 4, 633–636, Dec. 1953.

Author attacks the problem by means of successive approximations for (1) the transverse circulatory flow, and (2) change in main velocity distribution due to the transverse flow. Both are for steady state, i.e., for conditions far from the beginning of the bend.

For this purpose, he writes the equations of motion in the Lamb-Gromeko-Minchin form, in cylindrical coordinates, with variable turbulent viscosity coefficient. Then, in first approximation, disregarding higher inverse powers of bend radius and changes of the main velocities and of turbulent viscosity coefficient, he deduces the differential equation (4th-order) for the transverse flow function. He gives the boundary conditions with regard to skin friction, and says the problem may be solved by the Galerkin variational method.

Then, also disregarding higher inverse powers of bend radius and changes in turbulent viscosity-coefficient distribution, he deduces the differential equation (2nd-order) for the main velocity changes, to be solved by iteration.

Author claims having obtained solutions for circular and rectangular cross sections and approximate solutions for trapezoidal and triangular cross sections, and having checked them by experimental measurements, with good agreement. Some references are given to books and papers in Russian, by same author and others.

Reviewer observes importance of the transverse flow problem for hydraulic engineering. He checked author's deductions and found them correct; some inconsistencies in formulas are typographical mistakes not affecting the results. A logical extension of the subject would be: equations for further approximations

for steady state, and some study of the nonsteady state (at entrance and exit of bend). N. Krivoshein, Argentina

1711. **Vyzgo, M. S., Local scour beyond horizontal apron and falling nappe** (in Russian), *Gidrotekh. Stroit.* **23**, 5, 20–24, May 1954.

Formulas are developed for estimation of the length of apron and empirical values suggested for various roughness of its surface. Depth of scour can be computed for certain limited conditions. Idea of splitting a jump into two parts is suggested; these parts rotate in opposite directions and annihilate surplus of energy. S. Kolupaila, USA

Incompressible Flow: Laminar; Viscous

See also Revs. 1537, 1666, 1667, 1741, 1743, 1762, 1777, 1819, 1823)

1712. **Binder, R. C., Fluid mechanics, 3rd ed.,** New York, Prentice-Hall, Inc., 1955, x + 388 pp. $7.65.

The book is divided into two parts; Basic Relations, and Applications in Fluid Dynamics. The first part deals with relationships which must exist in any flow situation. The topics constituting this section include fluid properties, fluid statics, kinematics of fluid flow, dynamic or momentum equation, steady-flow energy equation, viscosity, and dimensional analysis and dynamic similarity. In this portion of the book, author shows a considered and well-planned presentation of the physics of fluid flow. The nonflow and steady-flow expressions of the first law of thermodynamics are the starting point for writing the traditional hydraulic equations.

The second part deals with the application of these principles to pipe flow of incompressible fluids, fluid meters, flow in curved paths, resistance of immersed bodies, dynamic lift, propulsion and craft motion, fluid machines, turbines, couplings, and torque converters, open channel flow, compressible flow with and without friction, fluid power and control systems, lubrication, unsteady flow, and noise. The same high standard of clarity is maintained in this portion of the book.

Applications are sufficiently diverse to maintain student interest and in such numbers as to allow a course based on this book to have a choice of emphasis. The book is recommended for use in a one-semester first course in fluid mechanics. It is adaptable to classes segregated according to engineering major. The book reads easily and the approach to elementary material is simple without being condescending. To the practicing engineer the book can serve as an introduction to some topics which have recently been given attention in the engineering curriculum.
C. R. Mischke, USA

1713. **Bitron, M. D., Atomization of liquids by supersonic air jets,** *Indust. Engng. Chem.* **47**, 1, 23–28, Jan. 1955.

Paper describes careful experiments on air atomization of a spray of dibutyl phthalate, at supersonic air velocities (from 460 to 680 mps). Air was discharged through one of a series of convergent-divergent nozzles, and the liquid was discharged transversely into issuing air stream. Samples of spray were collected on glass slides and measured under microscope. The slide holder was exposed to spray for only 0.01 sec. Volumetric flow ratio was constant at $Q_l/Q_g = 1.2 \times 10^6$, and loss by evaporation was considered to be negligible.

The results, expressed as Sauter mean diameter, varied considerably from one test to another at nominally same conditions, but, when the results of 10–12 experiments were pooled, the mean droplet size compared well with value calculated from Nukiyama-Tanasawa equation. Variation of air velocity had less effect on mean droplet size than would be expected from this equation, but the author concludes that the Nukiyama-Tanasawa equation is applicable to sprays formed by supersonic gas streams. Work is valuable, and result important, but it should be noted that range of variables was very limited; Sauter mean diameter varied only between 6.7 and 7.3 microns. E. Giffen, England

1714. **Carstoiu, I., Vorticity and deformation in fluid mechanics,** *J. rational Mech. Analysis* **3**, 6, 691–712, Nov. 1954.

A collection of numerous interesting differential-geometric ("kinematic") identities involving vorticity and rate of strain. The author obtained them in 1948; many are closely related to similar identities in C. Truesdell's "Kinematics of vorticity" [Univ. of Indiana Press, 1954]. In particular, identities of Zorawski and Beltrami are generalized. No applications are given.
G. Birkhoff, USA

1715. **Ingraham, R. L., Taylor instability of the interface between superposed fluids—Solution by successive approximations,** *Proc. phys. Soc. Lond.* (*B*) **67**, part 10, 418B, 748–752, Oct. 1954.

Method is described for finding the solution of nonlinear field equations by successive approximation. Second-order approximation is computed for the problem of the instability of liquid surfaces when accelerated in a direction perpendicular to their planes. The corresponding linearized problem was discussed by G. I. Taylor [AMR **4**, Rev. 757]. The paper derives the linear equations for the n-th order approximation, using the initial amplitude of the interface as the expansion parameter. The second approximation contains terms which involve not only integer multiples of the growth parameter (σ) given originally by Taylor but also $2^{1/2}\sigma$.

No analytical discussion is presented regarding the convergence of the method. This reviewer readily agrees with the author that the nonlinear approximation given in the paper will furnish a *qualitative* idea of the instability. It is noted that, while elementary trigonometric formulas are given in the paper (e.g., $\cos 2\alpha$ = etc.), the tedious and difficult justification of several steps is left to the reader. Other examples of the method would be of great interest. V. G. Szebehely, USA

1716. **Knapp, W. C., and Metzger, J. W., A graphical representation of the frictional losses in commercial pipe of air and steam flowing turbulently at low pressure,** ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-17, 15 pp.

Authors give a graph which permits rapid evaluation of pressure losses in pipes carrying air or steam at low pressures. They assume turbulent flow and they use Fanning equation to take into account compressibility of air or steam. They divide Fanning equation into two terms, F_1 and F_2; in each of them appears the product of two expressions, the one containing pipe diameter, the other fluid temperature.

Authors calculate F_1 and F_2 for rates of air flow in $^{10}/_{12}$-in. pipe at 68 F and determine two factors $C_{D1}(D)$ and $C_{D2}(D)$, which multiplied, respectively, by F_1 and F_2 give the pressure losses in pipe of diameter D, which carries the same rates of air as the $^{10}/_{12}$-in. pipe. Two analogous factors C_{T1} and C_{T2} take temperature into account.

In case of steam flow, the same F_1 and F_2 calculated as above for air flow in $^{10}/_{12}$-in. pipe are multiplied by the same C_{D1} and C_{D2} as for air and by two new factors C'_{T1} and C'_{T2}, dependent of temperature. The final graph, in which are plotted F_1 and F_2 against rates in lb/hr, C_{D1} and C_{D2} against D, C_{T2} and C_{T1} against T, is easy to use. M. Viparelli, Italy

1717. Pfkhteev, G. N., Determination of the two-dimensional potential motion of an incompressible fluid from given values of the direction of its velocity (in Russian), *Prikl. Mat. Mekh.* **18**, 3, 379–380, May/June 1954.

Let $Ve^{i\theta}$ be the velocity. Since θ and $-\ln V$ are conjugate harmonic functions, the velocity potential corresponding to given harmonics θ is readily found by quadratures.

J. H. Giese, USA

1718. Morgan, G. W., and Kiely, J. P., Wave propagation in a viscous liquid contained in a flexible tube, *J. acoust. Soc. Amer.* **26**, 3, 323–328, May 1954.

Authors study the propagation of pressure waves through viscous incompressible liquid filling an elastic, thin circular tube. Earlier treatment of the problem by others neglected viscosity and did not explain the increase of wave velocity c with increase in frequency ω of the disturbance. Witzig [Inaug. Diss. Bern, 1914], Lambossy [*Helv. physiol. Acta* **9**, 145, 1951], Karreman [*Math. Rev.* **14**, 8, 781, 1953], and Branson [*Bull. math. Biophys.* **7**, 181, 1945] consider the viscosity of the liquid, but their analysis, according to authors, is incorrect.

Navier-Stokes equations in cylindrical coordinates and the equations of motion of the elastic tube are simplified assuming "long" waves.

$$R/\lambda << 1,\ \lambda(\omega/\nu)^{1/2} >> 1,\ h/R << 1$$

where R and h are tube radius and thickness, $2\pi\lambda$ wave length, and ω frequency of disturbance. The boundary conditions are satisfied on $R = R_0$, the undisturbed radius.

For small viscosity $R_0(\omega/\nu)^{1/2} >> 1$, the Poisson ratio σ has considerable influence on c and damping factor K_2. For small viscosity and tube with internal damping, c remains unaltered but K_2 is modified. For large viscosity $R_0(\omega/\nu)^{1/2} << 1$, expressions are derived for c and K_2. With internal damping, both c and K_2 are modified. In both cases, damping increases with frequency.

Reviewer believes that the problem should be of special interest to physiologists.

S. D. Nigam, Germany

1719. Kostyukov, A. A., Formulas for the evaluation of the wave drag and lift forces of bodies submerged in fluids (in Russian), *Prikl. Mat. Mekh.* **18**, 2, 225–232, Mar./Apr. 1954.

Starting from the general formulas, well known in hydrodynamics, for the force of a fluid acting on a body, expressions are given for the wave drag and lift for hydromechanical singularities and bodies of arbitrary shape which move in a fluid of finite or infinite depth. Also given are expressions for the moments of the hydrodynamic forces acting on the bodies. *From author's summary.*

Author determines formulas for the lift and drag on submerged sources, dipoles, and on shapes of arbitrary form which could be ships. Results are compared with the previous work of Kochin [Coll. works, vol. II, p. 105], Khaskind [title source, **9**, 1945], Mitchell [*Phil. Mag.* **45**, 1898], and Havelock [*Proc. roy. Soc. Lond.* (*A*) **144**, p. 514, 1934].

M. D. Friedman, USA

1720. Jacobs, R. B., On the propagation of a disturbance through a viscous liquid flowing in a distensible tube of appreciable mass, *Bull. math. Biophys.* **15**, 395–409, 1953.

Author criticizes previous work by other investigators [see, e.g., Karreman, title source, **14**, 327–350, 1952; **15**, 109, 1953] on the grounds that their mathematical simplifications eliminate important effects and that their assumptions concerning the elastic properties of the tube material are unreal. An investigation is presented which, it is claimed, will probably apply to most actual systems and will show all the previously neglected effects. The analysis is based on a transformation of variables which renders the physically complicated boundary conditions simple, and on a subsequent expansion of the unknowns in power series in R_0/L (R_0, L the unstressed radius and length, respectively, of the tube), the first essential terms of which are found. Curves showing the variation of the propagation velocity of the fundamental mode of traveling waves with various parameters are given.

This reviewer questions the validity of the analysis for various reasons. (1) The elastic law assumed involves only one elastic constant, none analogous to Poisson's ratio for a linearly elastic material. Hence the possibly important effects of axial displacement of the tube wall as a result of circumferential strain are lost. (2) The frictional force exerted by the fluid on the tube wall is neglected. (3) It is assumed that the effect of the steady flow upon which waves are superposed is adequately accounted for by replacing the nonlinear terms $u\partial u/\partial x + v\partial u/\partial r$ in the axial equation of motion (x, r; u, v axial and radial coordinates and velocity components, respectively) by the single linear term $q_0\partial q^{(1)}/\partial x$, q_0 being the average steady velocity (a constant) and $q^{(1)}$ the axial perturbation. It is not at all clear that this assumption is warranted. First, the term arising from $v\partial u/\partial r$ as a result of the radial variation of the steady flow U, say, may in certain circumstances be as important as the term retained. Second, the effect of the radial variation of the steady velocity U may be important also in the term $U\partial q^{(1)}/\partial x$. (4) The parameter $\delta = R_0/L$ in powers of which solutions are sought, subject to the restriction $\delta << 1$, does not have any bearing on the study of traveling waves for which the tube must be assumed to have infinite length. The relevant ratio is R_0/λ, where λ represents the wave length of the disturbance. (5) The reviewer cannot understand why the first terms of the power series in δ for the unknowns (zero power of δ) represent the steady flow. (6) The derivation of the equations for the first important coefficients of the power series appears to be inconsistent with the assumptions.

G. W. Morgan, USA

Compressible Flow, Gas Dynamics

(See also Revs. 1543, 1664, 1712, 1733, 1745, 1747, 1776, 1782)

1721. Rosenhead, L., Bickley, W. G., Jones, C. W., Nicholson, L. F., Pearcey, H. H., Thornhill, C. K., and Tomlinson, R. C., A selection of graphs for use in calculations of compressible airflow, Oxford, Clarendon Press, 1954, x + 115 pp. 84s.

Volume is self-contained and complements "Tables for use in calculations of compressible airflow" [AMR **6**, Rev. 2580]. Most important tabulated material for isentropic flow and normal shocks is repeated. This volume presents conical flow values and many convenient variables in oblique shocks which were not tabulated. Mach number range is 1.0 to 5.0 or 0 to 5.0 where applicable.

Conical flow section presents: shock angle vs. free-stream Mach number M_1 for cone half angles θ_c 0(5)50°; for each θ_c, 5(5)30(10)50°, local Mach number in entire flow field vs. M_1 and M_c at cone surface; for same θ_c, flow deflections in entire field vs. M_1, and lastly, pressure coefficient at cone surface vs. M_1 for θ_c 5(2.5)25(5)50°.

Oblique-shocks section presents: flow deflection angle δ, downstream Mach number M_2 and upstream obliquity angle ζ_1 vs. M_1; M_2, $M_1 \sin \zeta_1$ and static pressure ratio vs. M_1 for various δ and ζ_1; stagnation and static pressure ratios vs. ζ_1 for various M_1; ζ_1 vs. M_1 for various δ and M_2/M_1 vs. δ for various M_1.

Two graphs present values for flows through an incident and reflected shock with entrance and exit flows parallel to the

straight boundary. Multiple entry graphs present: entrance obliquity angle ζ_1 vs. M_1 for various downstream obliquity angles ζ_3 and Mach numbers M_3; ζ_3 vs. over-all static pressure ratio p_3/p_1 for various p_2/p_1 and ζ_1.

Summary and multipage expanded graphs are used. Accuracy with expanded graphs should approach companion table values. The grid sizes vary between 0.07 in. and 0.10 in. Printing is excellent. Large number of figure indexes and definitions expedite use. Size, 15.3 in. by 11.7 in., may be a problem.

A. D. St. John, USA

1722. **Roberts, R. C., and Riley, J. D., A guide to the use of the M.I.T. cone tables,** *J. aero. Sci.* **21,** 5, 336–342, May 1954.

The second and third volumes of the M.I.T. cone tables have been found to be unsatisfactory in two respects. They have been criticized because of their inconvenient tabulation and because the theory on which they are based is inadequate near the cone surface. The former is eliminated by means of a coordinate transformation. Empirical evidence is presented to show the latter may be ignored in practice. The exact nature of certan numerical errors in the table is also pointed out.

From authors' summary

1723. **Oguchi, H., On the attached curved shock in front of an open-nosed axially symmetrical body,** *J. phys. Soc. Japan* **9,** 5, 861–866, Sept./Oct. 1954.

By calculating the local solutions near the nose of an open-end axially symmetric body, author deduced a relation expressing the initial curvature of an attached shock in terms of two principal curvatures of the body for both subsonic and supersonic flows behind the shock. It is shown that, as in the plane case, the initial curvature of shock becomes singular at Crocco's point; and, unlike the plane case, the singular behavior remains even when the wall in the flow direction is straight.

Y. H. Kuo, USA

1724. **Shibaoka, Y., On the shock wave formed by a concave bend,** *J. Inst. Polytech. Osaka City Univ. (B) Phys.* **4,** 5, 1–6, 1953.

Author has investigated the nature of the cusping of the envelope of the characteristics of a two-dimensional simple-wave flow along a smooth concave corner. The coordinate origin is taken as the point on the wall from which emanates the characteristic that passes through a cusp point, and it is assumed that the equation of the wall is given by $y = x^2 + ax^3$. The quantity a is then found as a simple function of μ_0, the Mach angle associated with the characteristic through the origin. A study of the second coefficients of a Taylor-series representation of the envelope in the neighborhood of the cusp point shows that, depending on the value of μ_0, the envelope branches out from the cusp point either toward increasing x and y values or toward decreasing x and y values. Computations are carried out for air ($\gamma = 7/5$). It should be noted that the results with respect to the direction of branching are restricted to the case where the wall shape is directly $y = x^2 + ax^3$, i.e., this equation cannot be considered as an approximation to a power-series representation of the wall shape in the neighborhood of the point of interest.

P. Chiarulli, USA

1725. **Oguchi, H., On the reflected wave in Mach reflection,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 353–358.

According to the procedure of Lighthill [AMR 3, Rev. 2716], author studies theoretically the diffraction of a shock wave of arbitrary intensity at a wedge of very small angle $2\,\delta$. Pressure and vector velocity are developed in power series of δ; in the differential equations, terms up to the order δ^2 are taken in account. For the reflected wave the equation $r - 1 = O(\delta^2)$ is valid for dimensionless polar coordinates (r,θ) appropriately chosen (cf. Tan's paper, AMR **5**, Rev. 1470, which author seems not to have known at that time]. The coefficient $(r - 1)\delta^{-2}$ is stated explicitly as a function of θ and represented graphically for two typical cases (subsonic and supersonic flow behind main shock); it becomes zero at the triple point and (in supersonic case) infinite at the contact point of the tangent from the wedge to the circle $r = 1$.

H. Schardin, Germany

1726. **Müller, W., The hodograph method of gas dynamics for the quadratically approximated adiabatic** (in German), *S. B. Mat.-Nat. Kl. Bayer. Akad. Wiss.* **1953,** 313–330, 1954.

The hodograph equation for the stream function of a subsonic gas flow may be transformed to Laplace's equation when the adiabatic gas law takes certain special forms. Apart from the well-known von Kármán-Tsien form, Sauer [AMR **6**, Rev. 2576] has given a more complex one involving three parameters. This enables it to be matched quadratically to the real adiabatic at a given point. Author extends the Sauer method to deal with flows with circulation, after the manner of Lin for the von Kármán-Tsien gas [*Quart. appl. Math.* **4,** 291–297, 1946]. This method is applied to subsonic flow past a biconvex airfoil, generated from the incompressible flow past a circular arc.

The Sauer adiabatic gives infinite sound speed for a certain minimum gas speed, so that stagnation points are excluded. Reviewer believes it is doubtful whether the approximation is any better in the large than the simpler one of von Kármán-Tsien. The presentation is not particularly clear.

H. C. Levey, Australia

1727. **Sagomonyan, A. Ya., The method of characteristics for the unsteady axisymmetric self-similar motion of a fluid** (in Russian), *Vestnik Moskov. Univ. Ser. Fiz.-Mat. Estest. Nauk* **8,** 12, 63–68, 1953.

An axisymmetric flow field is self-similar ("auto-model") if the velocity components, pressure, density, and entropy are functions of x/t and y/t only, where x, y are cylindrical coordinates. Author sketches methods to be used in three typical boundary problems which may occur in constructing numerical solutions of the characteristic equations for either linearized or nonlinearized isentropic flow.

J. H. Giese, USA

1728. **Stepanov, G. Yu., Construction of a grid with velocity distribution given on the circumference of a grid of circles** (in Russian), *Prikl. Mat. Mekh.* **17,** 6, 727–734, Nov./Dec. 1953.

Relying on Chaplígin's approximation for subsonic gas flow, the author reduces the problem to the determination of the function which maps the plane of the profiles (the z-plane) on the plane of the grid of circles (the m-plane), the modulus of dz/dm being known on the boundary. A numerical illustration is worked out in detail.

L. M. Milne-Thomson, England

1729. **Lance, G. N., The delta wing in a non-uniform supersonic stream,** *Aero. Quart.* **5,** part 1, 55–72, May 1954.

In this paper, the analysis of cone fields of higher order in linearized supersonic flow is developed in close analogy with the well-known theory of cone fields of order one [cf., e.g., S. Goldstein and G. N. Ward, AMR **4,** Rev. 803]. An elegant set of compatibility conditions is obtained by means of Euler's theorem on homogeneous functions. The analysis is applied to the flow round a delta wing with subsonic leading edges for a downwash distribution which is a quadratic function of the coordinates. Author states that he has checked his results by means of the method of hyperboloido-conal coordinates. It may be mentioned that the same method has been applied to this class of problems

by G. M. Roper [*Quart. J. Mech. appl. Math.* **1**, 327–343, 1948]. The results are interpreted in terms of a wing which is immersed in a nonuniform supersonic stream (e.g., a tail plane in the wake of the main plane). A. Robinson, Canada

1730. Krasil'shchikova, E. A., Unsteady motions of a wing of infinite span (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 2, 25–41, Feb. 1954.

This gives details of work reported earlier [AMR **8**, Rev. 1073]. Author applies to linearized arbitrary unsteady two-dimensional flows techniques for solving the two-dimensional wave equation that she has previously used for three-dimensional wings in linearized steady or harmonically oscillating flow [*Moskov Gos. Univ. Uchenye Zap.* **154,** *Mekh.* **4,** 181–239, 1951]. The velocity potential $\varphi(t, x, z)$ is obtained by superposition of sources of strength $\varphi_z(t, x, 0)$ on $z = 0$, where $\partial\varphi/\partial z = \varphi_z(t, x, z)$. In regions of $z = 0$, where the intensity $\varphi_z(t, x, 0)$ is not known a priori for a prescribed airfoil motion, it is found by solving a sequence of integral equations. The examples considered illustrate procedures for treating airfoil motions that start from rest and are accelerated to sub- or supersonic speeds, or are accelerated from long-established supersonic motion to subsonic speed. Also considered is the possibility of deforming the airfoil, as by extension or retraction of a flap. J. H. Giese, USA

1731. Fairbairn, A. R., and Gaydon, A. G., Comparison of the spectra produced by shock waves, flames and detonations, *Nature* **175,** 4449, 253–254, Feb. 1955.

1732. Bleviss, Z. O., and Struble, R. A., Some aerodynamic effects of streamwise gaps in low aspect ratio lifting surfaces at supersonic speeds, *J. aero. Sci.* **21,** 10, 665–674, 680, Oct. 1954.

See AMR **7,** Rev. 892.

Wave Motion in Fluids

(See also Rev. 1592)

1733. Hayes, W. D., Pseudotransonic similitude and first-order wave structure, *J. aero. Sci.* **21,** 11, 721–730, Nov. 1954.

Pseudotransonic similitude here developed is an extension of the von Kármán transonic similitude for supersonic flow, for conical flow first noted by W. Vincenti. As with this theory, mean-surface assumption is required and given theory is a first-order one. In slender-body theory the first-order wave structure is determined by the cross-sectional area distribution in most cases. For slender bodies, a similitude parameter and an additional similarity parameter are given for solution in the region away from body where wave systems are important. Other appropriate forms are two-dimensional, cylindrical, and conical flow and the flow at a distance from finite systems. Examples are described for two-dimensional airfoils, cusped nose on a body of revolution, and ring airfoil of high aspect ratio. As author notes, results of section on cylindrical flow agree with Berndt [AMR **5,** Rev. 1487]. F. Keune, Sweden

1734. Brillouët, G., Gravity waves in the neighborhood of a vertical wall (in French), *C. R. Acad. Sci. Paris* **239,** 15, 860–862, Oct. 1954.

Author deduces two groups of solutions for linearized problem of gravity waves when, at the origin ($x = 0$), we have a vertical obstacle.

Solutions of first group are

$$\varphi(x, y) = Ae^{y}\cos x - A_n \,{}_{y}\!\int^{\infty} e^{-t}\{r^{2n+1}\sin(2n+1)\theta\}_{\substack{x\\ y=t}}\, dt$$

In this equation A_n is a function of x, y and is $\Delta_2 A_n = 0$. Every solution of this group (with exception of $Ae^{y}\cos x$) is regular at the origin and not bounded at infinity.

Solutions of second group are

$$\varphi(x, y) = (A\cos x + B\sin x)e^{y} + (-1)^{n-1}2n!(B/\pi)\,{}_{y}\!\int^{\infty} e^{-t}\{\sin(2n+1)\theta/r^{2n+1}\}_{\substack{x\\ y=t}}\, dt$$

Every solution of this group has a polar singularity at the origin; at infinity we have $\varphi(x, y) \approx (A\cos x + B\sin x)e^{y}$.

Combining the two groups of solutions we may obtain regular solutions at the origin, not bounded at infinity, or regular solutions at infinity with a singularity at the origin, the lowest singularity being a logarithmic singularity. G. Supino, Italy

1735. Marnianskiĭ, I. A., Diffraction of waves around a submerged vertical plate (in Russian), *Prikl. Mat. Mekh.* **18,** 2, 233–238, Mar./Apr. 1954.

Author considers the plane problem of the propagation of running waves on the surface of a heavy fluid within which a vertical plate extends downward without limit. The effect is explained of the wave diffraction over the whole free surface and the pressure distribution along the plate is determined, depending on the wave parameters and the depth of submersion of the upper edge of the plate.

From author's summary by M. D. Friedman, USA

1736. Daily, J. W., and Stephan, S. C., Jr., Characteristics of the solitary wave, *Trans. Amer. Soc. civ. Engrs.* **118,** 575–587, 1953.

Paper summarizes theoretical and experimental work dealing with the problem of solitary waves. W. H. Munk, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 1710, 1712, 1819, 1860, 1881)

1737. Eckert, E. R. G., Diaguila, A. J., and Donoughe, P. L., Experiments on turbulent flow through channels having porous rough surfaces with or without air injection, *NACA TN* 3339, 45 pp., Feb. 1955.

Experimental investigations on the effect of fluid injection through a porous wall on the time mean velocity distribution, and the friction coefficient of a fully developed shear flow in a rectangular channel. The effect of roughness of porous wall was also investigated. The measurements were conducted at an *Re* of 6×10^4 with injection rates of flow varying from 0 to 17% of the flow in the main channel. The results indicate in a qualitative manner that the friction factor on the porous wall decreases with increase in rates of air injection, and that additional roughness on the porous wall have negligible effects on the mean velocity pattern with high injection rates.

Author correlates his results with the ratio of mean injection velocities based on the total area of the porous plate to the space mean velocity in the channel. Reviewer's opinion is that the influence of the injection will be dependent on the average velocity of the tiny jets as well as the total rate of injection. The transversal distance of influence of the jets is dependent on the kinetic energy it transports across the main stream. S. Eskinazi, USA

1738. Sandborn, V. A., Experimental evaluation of momentum terms in turbulent pipe flow, *NACA TN* 3266, 40 pp., Jan. 1955.

The mean and turbulent momentum terms in fully developed turbulent pipe flow were experimentally evaluated. The terms of

the longitudinal-direction momentum equation, obtained from the Reynolds equations of turbulent fluid motion, were experimentally evaluated in a 4-in.-diam pipe from total- and static-pressure data and hot-wire anemometer surveys. Measurement of the terms appearing in the radial-direction momentum equation indicates the existence of terms as large as or larger than the terms of the longitudinal-direction momentum equation.

Analysis of the turbulent stress tensor shows that the direction of principal stress was oriented nearly parallel to the wall in the region near the wall. Variation with Reynolds number of the longitudinal turbulent intensity at the center of the pipe indicates that the intensity at the center was of a universal nature.

A direct comparison was made with turbulence measurements obtained using the constant-current and constant-temperature systems of hot-wire anemometry. The two systems agree well within the experimental accuracy of the measurements. The constant-temperature measurements also agree with the measurements of turbulence presented by Laufer for the same Reynolds number. From author's summary by L. Talbot, USA

1739. Tamaki, H., and Oshima, K., Experimental studies on the wake behind a row of heated parallel rods, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 459–464.

Paper describes measurements of mean velocities and temperatures, of the intensities of velocity and temperature fluctuations, and of rates of momentum and heat transfer. The measurements of fluctuations and transfer rates were made with a three-wire assembly. The results are interpreted as confirming the analysis of Gran Olsson [*ZAMM* **16,** 257–274, 1936] which requires an eddy viscosity (or conductivity) inversely proportional to distance from the grid, although the measurements of the temperature distribution behind a single heated rod indicate a constant eddy conductivity.

The reviewer considers that all the observations may be described by a constant eddy viscosity and conductivity, which would be expected if the mean velocity *variation* is small compared with the fluctuations and if the turbulent energy decays as the inverse of the distance. These measurements, with those of Sato (see following review) form a valuable addition to our knowledge of the production of homogeneous turbulence by grids.

A. A. Townsend, England

1740. Sato, H., On the turbulence behind a row of parallel rods, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 469–473.

Hot-wire anemometer techniques have been used to measure mean velocities, shear stresses, and turbulent spectra and intensities for a grid of parallel prisms with the comparatively large mesh-diameter ratio of 5:1. The mean flow is found to vary periodically with wave length twice the mesh size, indicating a rather unusual flow around the grid elements. The nature of the turbulent motion during its approach to homogeneity and isotropy has been studied in detail, but it is discussed very briefly. The measurements, with those of Tamaki and Oshima (see preceding review) make up a valuable addition to our knowledge of the production of homogeneous turbulence, and it is to be hoped that a full and adequate analysis of them will follow.

A. A. Townsend, England

1741. Tani, I., and Kobashi, Y., Experimental studies on compound jets, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 465–468.

An interesting generalization of the free jet problem, viz., the turbulent spreading of a jet discharged into air streaming in the same direction. The main parameter is $I = U_j/U_s$ with U_j the jet velocity at the mouth of the nozzle in excess of U_s, the outer stream velocity. $I = \infty$ corresponds to a simple jet, and $I = -1$ to a wake of a body of revolution. Distributions of mean velocity and fluctuations are shown for several values of I. The main empirical result is a similarity law: $U/U_j = A\,(x/D)^{-1}\,F(\eta)$, with U jet velocity in excess of U_s, A a constant dependent on I, x and r axial and radial coordinates, D nozzle diameter, and $\eta = r/R$, with R value of r at which U is half the velocity on the axis. R is determined by the momentum equation. A detailed publication of numerical data would be appreciated.

K. Wieghardt, Germany

1742. Wieghardt, K. E. G., On a simple method for calculating laminar boundary layers, *Aero. Quart.* **5**, part 1, 25–38, May 1954.

In calculating approximately laminar boundary layers in axisymmetric and plane flows, author proposes to modify and extend the one-parameter (shape) method of Walz [AMR **4,** Rev. 1696], based on the momentum and energy equations. To simplify the calculations, it is assumed that for both axisymmetric and plane flows, the coefficients appearing in the total differential equations are universal functions of this shape parameter and therefore are determined by the special Falkner-Skan velocity profiles. In the plane case with linear pressure-gradient variation, a comparison with previous exact as well as approximate calculations has been made. For axisymmetric boundary layers, three different cases: (a) a half-body, (b) hemisphere and cylinder, and (c) $^1/_4$-caliber rounded head and cylinder have been calculated as examples. Y. H. Kuo, USA

1743. Wilkinson, J., Some examples of three-dimensional effects in boundary layer flow, *Aero. Quart.* **5**, part 1, 73–84, May 1954.

This is a study of a type of three-dimensional laminar boundary-layer flow that is nearly two-dimensional, the potential velocities being $U = U(\xi)$ and $V = \alpha\eta$, where ξ, η are orthogonal coordinates and α is a small parameter. The components U and V are called "main flow" and "cross flow," respectively. It is shown that to the first approximation the boundary-layer velocity components u and w are independent of α; i.e., the "independence principle" applies [as in a somewhat similar problem of Fogarty; AMR **4,** Rev. 4215]. The present author, however, goes beyond the first approximation and determines the effect of the cross flow on u and w; i.e., he calculates the terms of order α in these quantities. The cases studied are (1) $U = \xi^m$, for several values of m, and (2) $U = 1 - \xi$. The first is handled by solution of the differential equations and also, for comparison, by a Pohlhausen procedure. The second is treated by the Pohlhausen procedure only. In both cases it appears that the existence of the cross flow tends to increase the skin friction and to delay separation of the main flow. Doubt is cast on the accuracy of the latter conclusion because of known inadequacies of the methods near separation, but it is suggested that the general tendencies are correct. W. R. Sears, USA

1744. Fricke, C. L., and Smith, F. B., Skin-temperature telemeter for determining boundary-layer heat-transfer coefficients, *NACA RM* L50J17, 22 pp., Mar. 1951. (Declassified from Confidential, Aug. 1954.)

A method of experimentally determining boundary-layer heat-transfer coefficients by telemetering the skin temperatures of supersonic rockets is given. A platinum resistance-wire temperature-sensing element developed to indicate accurately the rapidly changing skin temperature is described and the over-all accuracy of the instrumentation is discussed.

From authors' summary

Aerodynamics of Flight; Wind Forces

(See also Revs. 1732, 1765, 1777, 1814)

1745. Van Dyke, M. D., Subsonic edges in thin-wing and slender-body theory, *NACA TN* 3343, 26 pp., Nov. 1954.

A simple technique is suggested to improve thin-wing theory near a subsonic leading edge where it is shown to fail because it predicts an infinite velocity which actually does not exist. Author removes the singularities by applying a correction factor obtained by considering exact solutions for the flow around simple bodies which approximate the wing near the edge. Hence, correction formulas for incompressible first- and second-order solutions for two-dimensional airfoils are given and compared to earlier similar results by Lighthill [AMR **5**, Rev. 2089] and Riegels [*Ing.-Arch.* **XVI**, pp. 373–376, 1948]. Comparisons with exact solutions show a striking improvement of thin-wing theory.

A correction formula for a rounded leading edge in compressible flow is derived by using the Rayleigh-Janzen approximation for the subsonic flow around a parabola. As an application, the pressure on a flat elliptical cone at $M = (2)^{1/2}$ lying inside the free-stream Mach cone is calculated.

There is also a brief consideration of slender bodies of revolution. In particular, it is found that the rules for round-nosed airfoils in incompressible flow also apply to round-nosed bodies.

M. Landahl, Sweden

1746. Bromm, A. F., Jr., Investigation of lift, drag, and pitching moment of a 60° delta-wing-body combination (AGARD Calibration Model B) in the Langley 9-inch supersonic tunnel, *NACA TN* 3300, 18 pp., Sept. 1954.

Results are presented from tests of the AGARD Calibration Model B in the Langley 9-inch supersonic tunnel. Measurements were made of the lift, drag, and pitching moment at Mach numbers of 1.62, 1.94, and 2.41 and at a Reynolds number, based on body length, of approximately 3.0×10^6. The zero-lift drag data compared favorably with available data and were in the proper sequence for the effects of Reynolds number.

From author's summary

1747. Nocilla, S., On the problem of delta wing with arbitrary dihedral and first-order incidence and yaw angles at supersonic speeds (in Italian), *Aerotecnica* **34**, 3, 126–141, June 1954.

Author deals with the case of both leading edges within the Mach cone from the vertex. In the Stewart complex plane, the problem is reduced to a Dirichlet-Neumann doubly mixed problem in a doubly connected region. Application of potential theory leads to two integral equations. A power-series solution in the dihedral angle β is obtained. When only terms in β are retained, results obtained by Stewart [*Quart. appl. Math.* **4**, 3, 1946], Heaslet [AMR **1**, Rev. 499] and Robinson [AMR **2**, Rev. 1435] are found as particular cases. To this approximation, zero yaw and dihedral solutions and zero angle-of-attack solutions can be superposed.

A second approximation obtained retaining terms of order β^2 is shown to follow very closely the first approximation up to values of $\beta = 15°$. Author believes that such second approximation can be considered satisfactory for all values of the dihedral angle β.

L. Napolitano, USA

1748. Vincenti, W. G., Dugan, D. W., and Phelps, E. R., An experimental study of the lift and pressure distribution on a double-wedge profile at Mach numbers near shock attachment, *NACA TN* 3225, 43 pp., July 1954.

An account is given of measurements at low supersonic speeds of the pressure distribution on a double-wedge profile. The results cover the Mach number range from 1.166 to 1.377, which brackets the value (1.221) for bow-wave attachment at zero angle of attack. The results are discussed and compared with the findings of the transonic small-disturbance theory.

From authors' summary

1749. Nonweiler, T., A resume of maximum lift data for symmetrical wings with various high lift aids, *Coll. Aero. Cranfield Rep.* no. 5, 31 pp., Mar. 1954.

An attempt is made to summarize the existing data on the value of low-speed $C_{L_{max}}$ of wings, in the absence of a fuselage and without including information on stalling incidence or pitching moment. It is limited to the consideration of unswept wings and those of delta planform, which have symmetrical sections; there is some discussion of the maximum lift increments due to the use of flaps of various kinds.

From author's summary

1750. Carros, R. J., and James, C. S., Some new drag data on the NACA RM-10 missile and a correlation of the existing drag measurements at $M = 1.6$ and 3.0, *NACA TN* 3171, 24 pp., June 1954.

Measurements of the zero-lift total drag of the NACA RM-10 missile were made on gun-launched, free-flight models at Mach numbers of 1.6 and 3.0 and corresponding Reynolds numbers of 3.0 million and 5.0 million. Results showed transition location to have an important effect on the drag. Results of this and several other investigations were correlated on the basis of considerations of Mach number, Reynolds number, transition location, and heat-transfer effects.

From authors' summary

1751. Bryson, A. E., Jr., Evaluation of the inertia coefficients of the cross section of a slender body, *J. aero. Sci.* 21, 6, 424–427, June 1954.

The determination of all the aerodynamic forces and moments (except drag) on a rigid slender body due to all possible motions of the body (except high-frequency oscillations or step motions) reduces, for a certain large class of slender configurations, to finding the six components of the symmetric inertia coefficient tensor of the cross section of the body. The evaluation of all six of these coefficients is given in terms of the coefficients of the Laurent series expansion of the conformal mapping function that maps the cross section onto a circle. As examples, the apparent additional masses of the cross section of a wing-elliptic body-vertical tail configuration and the apparent additional moment of inertia (which determines the roll damping) of the cross section of a configuration with n equal, equally spaced fins are found.

From author's summary

1752. Pröll, A., Contribution to the problem of flight with flapping wings (in German), *Öst. Ing.-Arch.* **8**, 2/3, 189–199, 1954.

The observation of Lilienthal, according to which the resistance coefficient in wing flapping is, in part, considerably higher than the coefficients known for stationary motions, is proved on the basis of a shock-elastic conception and is backed by examples. Furthermore, stress is laid on the advantages of a flapping wing drive. It is also demonstrated that from the aerodynamical viewpoint the flapping wing airplane is really possible and presents a great number of advantages. For the time being, these planes cannot be built, as the building materials available are incapable of absorbing the great mass acceleration, and, in addition, no suitable drive has been designed for converting the high speed of the motor into the low speed of the flapping wings.

From author's summary

1753. **Fisher, L. R., and Fletcher, H. S., Effect of lag of sidewash on the vertical-tail contribution to oscillatory damping in yaw of airplane models,** *NACA TN* 3356, 38 pp., Jan. 1955.

Two models were tested which permitted, in effect, a systematic variation of the sidewash gradient at the vertical tail. For the first model, this variation was accomplished by mounting auxiliary fins forward of the vertical tail; for the second model, it was done by altering the vertical location of the wing on the fuselage. The unsteady damping-in-yaw and directional-stability parameters are compared with the steady derivatives obtained for the same models to establish the effects of the sidewash and the lag of the sidewash on these lateral stability derivatives.

From authors' summary

1754. **Burk, S. M., Jr., Analytical determination of the mechanism of an airplane spin recovery with different applied yawing moments by use of rotary-balance data,** *NACA TN* 3321, 43 pp., Dec. 1954.

Paper presents an analysis of the equations of motion of an airplane initially in a spin and being acted upon by an aerodynamic yawing moment. The applied yawing moment results in recovery from the spin, and a step-by-step numerical solution of the six nonlinear equations of motion gives the time variation of the angle of attack and sideslip, linear and angular velocities, and accelerations.

The aerodynamic data used for the step calculations were obtained on the rotary balance of the Langley free-spinning tunnel, and the assumptions include negligible effect of accelerations on the stability derivatives and zero spin radius at all times.

Reviewer believes considerable insight is gained into the mechanism of spin recovery from a study of the paper; and further analyses, possibly by computing-machine methods based on more extensive knowledge of the stability derivatives under the nonlinear conditions, would be profitable. R. E. Bolz, USA

1755. **Papers on shimmy and rolling behavior of landing gears presented at Stuttgart conference Oct. 16 and 17, 1941,** *NACA TM* 1365, 233 pp., Aug. 1954. (Translation of "Bericht über die Sitzung Flattern und Rollverhalten von Fahrwerken am 16./17. Oktober 1941 in Stuttgart," *Lilienthal-Gesellschaft für Luftfahrtforschung,* Bericht 140.)

Report is a compilation of papers dealing with the general problem of the rolling behavior of landing gears with particular attention to the three subjects of fundamental properties of elastic tires, wheel shimmy, and veering-off or ground looping. These papers either present, summarize, or reference most of the major theoretical and experimental results obtained by German investigators on these subjects up to 1941.

Four papers deal primarily with the fundamental properties of elastic tires. "Stiffness of various tires," by *H. Schrode,* presents experimental data on the vertical, lateral, and torsional stiffness of five tires having considerably different shapes. These data indicate that considerable variations in tire stiffness can be obtained by variation of tire shape. "Lateral guiding forces on obliquely running airplane tires," by *R. Harling,* presents experimental data on the lateral stiffness and cornering force for a tire at several vertical loadings and inflation pressures, and also discusses the effects of the type of runway surface on the cornering characteristics. "Force distribution in the contact surface between tire and runway," by *P. Kraft,* presents experimental measurements of the distribution of normal and tangential stresses between tire and runway for a tire under unyawed and yawed rolling conditions. "Sideslip and guiding characteristics of the rolling wheel," by *H. Fromm,* is a paper primarily concerned with a theoretical study of the steady yawed rolling of elastic tires. Equations for the variation of lateral or cornering force with yaw angle, obtained under several alternate simplifying assumptions, are presented and are found to give results in reasonable agreement with experimental results.

Five papers deal primarily with the wheel-shimmy problem. In "Brief report on the history of the theory of wheel shimmy," *H. Fromm* presents a short discussion of most of the fundamental tire properties needed in the development of a wheel-shimmy theory, and presents a derivation based on these properties of a kinematic equation governing the rolling motion of elastic tires. Fromm also briefly discusses and points out some limitations in other previously published theories of wheel shimmy. "Comments on two American research reports," by *E. Marquard,* is largely a summary of the wheel-shimmy theories of Kantrowitz and Wylie. The paper "Shimmying of a pneumatic wheel," by *B. v. Schlippe* and *R. Dietrich,* and some supplementary discussions of this paper by the authors and *H. Fromm* in the Appendix of the report provide one of the most advanced existing theoretical analyses of the problem of the general rolling motion of elastic tires and demonstrate the application of this theory to the wheel-shimmy problem. Some limited experimental data are presented which partly confirm the validity of the theory. *P. Riekert,* in "Fundamental perceptions on wheel shimmy," presents a brief discussion of the primary factors which influence the occurrence and intensity of wheel shimmy. Some experimental data are presented which indicate the effects of rolling velocity, wheel loading, trail, and coefficient of friction on the shimmy behavior. The paper "Investigation of tail-wheel shimmy on the model Me 110," by *M. Renz,* presents some experimental shimmy data obtained during full-scale tests of an Me-110 airplane.

Four papers present some discussion and simplified analyses of the veering-off or ground-looping tendency of aircraft equipped with nose-wheel and tail-wheel-type landing gears with fixed or swivelable nose or tail wheels. These are: "Veering-off in take-off and landing," by *F. N. Scheubel;* "Veering-off (ground looping) of aircraft equipped with tail-wheel landing gears," by *E. Maier;* "Rolling stability of airplane landing gears and resultant requirements for swiveling wheels," by *L. Huber;* and "On the mechanics of the rolling of an airplane with a nose-wheel landing gear," by *T. E. Schunck.*

The paper "Experiences in flight operation," by *E. Hoffmann,* presents a brief discussion of the extent and nature of landing-gear difficulties experienced in flight operations.

R. F. Smiley, USA

1756. **Horne, W. B., Stephenson, B. H., and Smiley, R. F., Low-speed yawed-rolling and some other elastic characteristics of two 56-inch-diameter, 24-ply-rating aircraft tires,** *NACA TN* 3235, 108 pp., Aug. 1954.

The low-speed (up to 4 mph) cornering characteristics of two 56 × 16, type VII, extra-high-pressure, 24-ply-rating tires were determined for a range of vertical loadings, yawed angles, and tire inflation pressures. Locked-wheel drag tests were also made for one vertical-load condition. The quantities measured included cornering force, drag force, self-aligning torque, pneumatic caster, vertical tire deflection, rolling radius, and relaxation length. Some supplementary tests were made which included measurements of tire footprint area, vertical-load-deflection characteristics, and variation of tire radius and width with inflation pressure.

Results indicated that the normal force reached a maximum at between 14° and 18° yaw. The self-aligning torque increased with yaw angle up to between 5° and 8° yaw, where a maximum was reached. Increasing the yaw angle beyond this point tended to decrease the self-aligning torque considerably. The pneumatic caster was a maximum at small yaw angles and tended to decrease in value with increasing yaw angle. The yawed-rolling and slid-

ing drag coefficients of friction both tended to decrease in magnitude with increasing average bearing pressure. In general, the test results indicate that the relaxation length decreases with increasing vertical tire deflection and increasing inflation pressure.

From authors' summary

1757. Souriau, J.-M., On airplane stability (in French), *ONERA Publ.* no. 62, x + 99 pp., 1953.

Report deals with the analytical determination of the dynamic stability of airplanes. Author examines the hypotheses usually employed in the determination of airplane stability and notes that the linearization method appears to yield the most generally satisfactory results. He also points out that the hypothesis of incompressibility ceases to be valid for rapidly changing motions, whatever the flight speed.

The equations of motion are developed by means of the Lagrange-Hamilton principle for the case of an airplane, susceptible to elastic deformations, flying in a perfect compressible fluid. The equations are then linearized and are presented in matrix form. By applying the method of linearization directly to the Lagrange function and treating the corresponding variational problem as a space-time quadridimensional system, the author is able to include the study of shock waves and energy changes within the bounds of the linearization.

This leads to a general uniqueness theorem for the flow with finite energy, starting from rest, which imposes no supplementary conditions. It is shown that the Kutta-Joukowsky condition, in its domain of validity, characterizes the steady flow which is obtained starting from rest.

The Laplace transform is employed in the solution of the equations. By using the Laplace transform the mechanics problem is separated from the aerodynamic problem. A direct physical interpretation of the symbolic solution is given. It is shown that if the real part of the symbolic variable is positive, the energy relations may be interpreted in the transformation with the uniqueness theorem. In the case of large values of the symbolic variable, a term appears in the solution which may be interpreted as the effect of shock waves in the flow.

A necessary and sufficient condition for stability at a given flight speed is given.

The method is illustrated in the case of a plane wing of arbitrary planform in subsonic flow and also for swept and nonswept wings in cylindrical flow.

W. H. Shutts, USA

1758. Rotta, J., Mechanics of the performance of jet propelled aircraft (in German), *Z. Flugwiss.* **1**, 4, 92–99, Sept. 1953.

Paper considers turbojet-powered aircraft performance problem with assumption of no compressibility effects. Results include characteristic speeds for climb, etc., and comparison with those for propeller-driven aircraft. A figure of merit for performance is introduced. Approach is similar to that generally used by practicing aerodynamicists in this country.

E. S. Rutowski, USA

1759. Maruo, H., Two-dimensional theory of the hydroplane, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 409–415.

Earlier investigations on the subject were based on (1) "Wing analogy" (H. Wagner) neglecting gravity, or (2) "pressure point theory" (Lamb). Author solves this problem for a given form of the gliding surface using linear wave theory. The pressure p on the bottom is calculated from an integral equation by introducing for p a trigonometric series with unknown coefficients. Explicit results illustrated by graphs are communicated for the flat plate; the lift coefficient can be calculated from the approximate formula $C_L = \beta/(1/\pi + 1.477\kappa_0)$; β angle of incidence; $\kappa_0 = 1/2F^2$ with F the Froude number referred to the chord length l, $F = u/(gl)^{1/2}$; the resistance being in this case, obviously $R = \beta L$. The resistance in this, as in the general case, is due to spray and to wave formation; a graph shows the magnitude of these resistance components for the plate as function of κ_0.

Because of the spray generation and other reasons, a correction has to be applied to the pressure distribution in the region near to and ahead of the stagnation point (graph).

G. P. Weinblum, Germany

1760. Crim, A. D., Gust experience of a helicopter and an airplane in formation flight, *NACA TN* 3354, 12 pp., Dec. 1954.

A single-rotor helicopter and an airplane have been flown in formation in rough air for the purpose of measuring and comparing the responses of the aircraft to gusts. Rough-air flights were also made by the helicopter alone at several airspeeds over the same ground path.

The results indicate a somewhat greater gust alleviation for the helicopter than for the airplane over the speed range investigated. In addition, a substantial effect of speed on the normal accelerations of the helicopter due to gusts was observed.

From author's summary

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 1753)

1761. Mendelson, A., and Carroll, R. W., Lift and moment equations for oscillating airfoils in an infinite unstaggered cascade, *NACA TN* 3263, 46 pp., Oct. 1954.

Exact equations are derived for the oscillatory aerodynamic forces acting in an unstaggered cascade of airfoils fluttering in potential flow. Aerodynamic coefficients similar to those of the isolated airfoil are obtained as functions of the cascade geometry and the phasing between successive blades; the phasings considered are zero, 90°, and 180°. It is shown that 90° is a special case of 180° phasing. These aerodynamic coefficients are plotted for the special case when all the airfoils are vibrating in bending in phase (360° phasing). It is shown that the effect of cascading for this case is to reduce greatly the aerodynamic damping. From authors' summary by J. R. Schnittger, Sweden

1762. Marchetti, M., Case of permanent flow in elastic tubes (in Italian), *Energia elett.* **30**, 2, 65–79, Feb. 1953.

Paper is a theoretical analysis of Banki's experiment concerning essentially the flow through a very elastic tube submerged under an adjustable level of water. Author considers the steady state and uses the Bernoulli equation; an interesting analogy appears with the familiar hydraulic notions of specific energy and critical velocity. The balance of energy in the process of passing from one steady state to another is next considered. Reviewer believes that further discussion is needed on this point.

A. Craya, France

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 1567, 1568, 1571, 1615, 1795, 1798, 1813, 1816, 1832, 1835, 1845, 1846, 1862, 1889)

1763. Wallace, F. J., and Nassif, M. H., Air flow in a naturally aspirated two-stroke engine, *Proc. Instn. mech. Engrs.* **168**, 18, 515–544, 1954.

The scavenging process of a naturally aspirated (blowerless) two-stroke cycle engine was investigated analytically by the theory of waves of finite amplitude, and experimentally in a

motored engine in which the exhaust release pressure of the firing engine has been simulated. Charts were worked out, which make application of wave theory to induction and exhaust easier. Good experimental agreement was shown. By correct timing, excellent fitting of cylinder can be obtained. Tuned exhaust is more important than tuned induction. For engines of dynamic similarity the external pipe system must be to scale, while the engine speed must be in inverse proportion to scale ratio. Ejector and expansion chamber attached to the exhaust pipe improved performance little, but a diffuser raised the best air delivery ratio spectacularly (from 64% to 110%). The Hopkinson-Schweitzer equation for the scavenging efficiency of perfect mixing has been extended to include perfect mixing. Reviewer believes the authors' criticism of the authors named, for neglecting the loss of charge during the blowdown period, is unjustified.

Blowerless two-stroke cycle engines are seldom used, but much of the information presented is useful for blown engines as well.

P. H. Schweitzer, USA

1764. List, H., The charging processes of internal-combustion engines with special reference to the two-stroke cycle, *Instn. mech. Engrs. Proc. Auto. Div.* **3,** 45–56, 1953/1954.

Author treats two problems—manifold gas flow, and scavenging. Assuming gas motion in manifolds conforms to acoustical theory, author calculates gas motion and compares with experimental results in manifolds. Calculated scavenging results are based on assumption that they are governed strictly by laws of diffusion. Author discusses scavenging in variety of two-stroke engines and makes one comparison with four stroke. Calculated and experimental scavenging parameters were in good agreement, but author fails to show methods of calculation. Experimental results were obtained by static testing or by sampling operating engines. Paper has 14 British discussors.

Reviewer feels use of paper is severely limited by lack of clarification of theoretical procedures used and agrees with most discussors that scavenging is not controlled strictly by diffusion.

F. W. Bowditch, USA

1765. White, J. O., and Pasman, J. S., Installation and operating experience with a naval gas-turbine-powered landing craft, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-43, 12 pp.

1766. Anderson, H. H., Modern developments in the use of large single-entry centrifugal pumps, *Instn. mech. Engrs.*, 15 pp., 1954.

In parallel with the electric motor and the steam turbine, which provide suitable high-speed power, the centrifugal pump has been developed to a high degree of reliability and efficiency. This paper describes a recent step in this development, namely, the research, manufacture, and adoption of single-entry pumps, combined with their driving mechanisms, for medium and large power duties.

From author's summary

1767. Cavicchi, R. H., and English, R. E., A rapid method for use in design of turbines within specified aerodynamic limits, *NACA TN* 2905, 72 pp., Apr. 1953.

Authors have transformed the conventional thermodynamic equations for one-dimensional streamline flow through turbine blades into equivalent systems of charts and tables, permitting tentative solutions of the following basic problems in turbojet engine design: Selection of numbers of stages and optimum work division among them; selection of the design having minimum leaving loss for given number of stages; proximity of operation to certain aerodynamic design limits imposed upon the exit velocities in each stage. The equations are derived in detail, while charts and tables are given for five different combinations of the design limits. Five simplifying but reasonable assumptions regarding the velocity pattern underlie all calculations. Sample calculations are presented for single-stage turbine with light and heavy load, single-stage compressor with supersonic high-weight flow, and multistage turbine. The method is intended to serve as the starting point for conventional detailed analysis.

E. F. Lype, USA

1768. Chilton, E. G., and Handley, L. R., Pulsation absorbers for reciprocating pumps, *Trans. ASME* **77,** 2, 225–229, Feb. 1955.

See AMR **7,** Rev. 2251.

1769. Senoo, Y., Research on peripheral pumps, *Rep. Res. Inst. appl. Mech. Kyushu Univ.* **3,** 10, 53–113, July 1954.

1770. Senoo, Y., Influence of the suction nozzle on the characteristics of a peripheral pump and an effective method for its removal, ibid., **3,** 11, 129–142, Aug. 1954.

Author, in the first paper, has made a thorough investigation of peripheral pumps (turbine pumps). He examines the differences between the experimental and theoretical behavior and, as a result, suggests, in the second paper, means of improving performance, chief of these being rectification of faults in suction nozzle.

The two papers are considered to be of value to designers and operators of these pumps. H. H. Anderson, Scotland

Flow and Flight Test Techniques

(See also Revs. 1695, 1756, 1884, 1890)

1771. Newman, B. G., Lag in airborne pressure measuring systems, *Nat. aero. Establ. Canad.* LR-100, 33 pp., 14 figs., Apr. 1954.

There is often a significant pressure drop, or lag, in the tubing joining a pressure source to a measuring instrument when the pressure is changing with time. This lag may be considered in two parts: (1) the acoustic lag due to the time required for a pressure disturbance to be propagated along the tubing, and (2) the viscous lag due to the pressure drop associated with the flow down the tubing. The latter component of lag is usually the larger. It is discussed here theoretically and, following a series of ground measurements on simple systems, a semiempirical formula for viscous lag is obtained. This differs in detail from that of previous investigators. The formula applies generally to systems comprising a number of tubes of various diameters connected to several measuring instruments. It assumes that the flow down the tubing is laminar without slip and these limitations are discussed. The effect of bends and an annular tube in the system is considered. A value for the acoustic lag is added and the resulting formula is applied to airborne systems comprising altimeters, airspeed indicators, and Machmeters, on the assumption that conditions within the tubing are isothermal.

The treatment only applies when the time rate of change of pressure is approximately constant; thus the lag in violent maneuvers, for example, is excluded.

From author's summary by M. S. Macovsky, USA

1772. Hutton, S. P., The prediction of venturi-meter coefficients and their variation with roughness and age, *Proc. Instn. civ. Engrs.* **3,** part 3, 1, 216–235, Apr. 1954.

The elementary theory of the venturi tube is recounted in order to analyze the influence of various factors on the venutri-meter co-

efficient C. It is shown that these influences fall into two main classes: (1) "External" effects caused by upstream flow conditions and installation; (2) "internal" effects depending on the geometry and surface finish of the meter.

In the case of meters installed downstream of a long straight length of piping, the particular effects of roughness of the upstream piping and of the meter itself are considered.

A theory is developed which gives good agreement with code values for the effect of various sizes of rough pipe upstream of the meter. It is shown that the code values are consistent with pipe-flow theory and correspond to a roughness equivalent to cast iron. This theory may be useful for calculations involving other roughnesses and also for extrapolating beyond the range of pipe sizes (2 to 8-in. diam) quoted by the codes. It is also shown, as in the codes, that for meters with $m \leq 0.3$, changes in C caused by external roughness are likely to be negligible in practice.

From author's summary

1773. Oppenheim, A. K., and Chilton, E. G., Pulsating-flow measurement—a literature survey, *Trans. ASME* **77,** 2, 231–245, Feb. 1955.

See AMR **7,** Rev. 2582.

1774. Saake, M. G., Counting-timing technique for flow control, *Instruments* **27,** 6, 938–939, June 1954.

A counter and an automatic-reset timer, used with a contact-type positive-displacement flowmeter and solenoid valve, is a flexible device for automation of flow processes. Such "digital" techniques are particularly adaptable to batch and proportioning applications.

From author's summary

1775. Speak, G. S., and Walters, D. J., Optical considerations and limitations of the schlieren method, *Aero. Res. Counc. Lond. Rep. Mem.* 2859, 25 pp., Jan. 1950, published 1954.

Aberrations present in lens and mirror schlieren systems are discussed and it is concluded that the twin mirror system is, in general, the best. Experimental procedure of setting up a schlieren system is given. Santon's system, in which a small aperture is used instead of a knife edge, and Ronchi's grid method are described.

General schlieren system theory is derived. Relationship between deflection of a ray and refractive index distribution is valid from the point of view of both geometric and physical optics, but the connection between deflection and change in illumination in final focal plane depends on whether the geometric or the wave theory is used. Estimates of limiting sensitivity based on geometric theory are unreliable. Typical examples are worked out using wave theory and it is concluded that schlieren system offers very high qualitative sensitivity but is not recommended for quantitative work at high sensitivity.

This is a useful paper for schlieren design, particularly as points investigated were subject of experiments by authors.

J. Lukasiewicz, Canada

1776. Teofilato, S., A new laboratory for experimental research in high-speed flow (in Italian), "Mémories sur la mécanique des fluides," *Publ. sci. tech. Min. Air, Paris,* 319–338, 1954.

At the Institute of Hydraulics of the University of Rome a new experimental apparatus has been built to generate a controlled flow of extremely smooth water in a sheet, controlled by a pressure (reverse) weir under adjustable heads. Models of proper cross sections and supported by a sensitive balance are inserted in the current (as a boat would be) and accurate measurements are made of dynamic variables, while typical flow disturbances are recorded by photographic means and by angular measurement of shock waves as generated by the model prow or other discontinuities.

The article describes also some initial research projects which have shown fair consistency with theoretical data but have pointed out the need for determining a range of tunnel corrective calibrations. Significant pictures of shock wave and other flow disturbances are included in appendix.

Cited references bring out previous work by the author on utilizing the similarity of hydrodynamic flow to supersonic gas flows for research in the latter.

B. Posniak, USA

1777. Keith, A. L., Jr., and Schiff, J., Low-speed wind-tunnel investigation of a triangular sweptback air inlet in the root of a 45° sweptback wing, *NACA TN* 3363, 65 pp., Jan. 1955.

Results of a low-speed study of a 45° sweptback wing-root air-inlet configuration believed suitable for transonic-speed airplanes are presented. The inlet-configuration lift and drag characteristics are compared with those of a basic model. Boundary-layer growth along the fuselage nose, inlet total-pressure recoveries, and static-pressure distributions over the inlet and wing surfaces are presented for wide ranges of inlet-velocity ratio and angle of attack.

From authors' summary

1778. Kenney, J. T., and Webb, L. M., A summary of the techniques of variable Mach number supersonic wind tunnel nozzle design, *AGARDograph* 3, 133 pp., Oct. 1954.

A prerequisite for successful wind-tunnel tests at supersonic speeds is a uniform, parallel gas stream at a desired Mach number. Authors consider many of the nozzle arrangements which achieve these conditions, but are concerned primarily with the two-dimensional, variable-Mach-number nozzle of the continuous-curvature, flexible-plate type.

The theoretical considerations leading to the design and construction of nozzles applicable to nonrarefied, ambient-stagnation-temperature air flows are outlined in comprehensive and readily usable detail. A design method for rapidly arriving at aerodynamic and structural compatibility, the testing and calibration of nozzles, and the economics of supersonic nozzles as influenced by size, complexity, and purpose are all completely and lucidly discussed.

H. A. Stine, USA

1779. Anonymous, Transonic and low-speed wind tunnels, *Engineering* **177,** 4612, 777–781, June 1954.

Two new wind tunnels have recently been completed for the de Havilland Aircraft Company, Ltd., Hatfield, Hertfordshire—a high-speed tunnel capable of operating at Mach numbers ranging from 0.8 to 1.6, with a working section approximately 2-ft square and a low-speed tunnel for speeds up to 250 fps, capable of accommodating models of 6-ft wing span.

From summary

1780. Ferri, A., and Bogdonoff, S. M., Design and operation of intermittent supersonic wind tunnels, *AGARDograph* 1, 108 pp., May 1954.

An integrated account is presented of the design and operating requirements of intermittent supersonic wind tunnels. Tunnels used between an atmospheric inlet and a vacuum sphere, or from a highly pressurized inlet at atmosphere, or a combination of both are described.

The pressurized inlet type of tunnel is favored, owing to its greater flexibility in extending its usefulness in the transonic and hypersonic regimes as well as its desirable range of flow Reynolds numbers in the supersonic regime.

The blow-down tunnel has found a wide acceptance among research groups in the United States, owing to its low initial and

operating costs, small power requirements, simple construction, ease of operation, and relative safety (with the atmospheric inlet).

The report will be appreciated especially by those who are contemplating the design of a supersonic wind tunnel. Very useful graphs and design illustrations as well as important references are included. An appendix listing the equations and their derivation as well as the tables used in the construction of the graphs would have enhanced the value of the report.

The authors, who have had long and notable careers in supersonic research and development, are to be commended for this survey. I. I. Glass, Canada

1781. **LaBerge, J. G., Supersonic wind-tunnel tests of eleven small aspect-ratio wings,** *Nat. aero. Establ. Canad.* LR-97, 73 pp., Mar. 1954.

The lift, drag, and pitching moment characteristics of eleven small-aspect-ratio of half-wing models mounted on a reflection plate were determined in the range of Mach numbers from 1.4 to 2.5 in the NAE 10-in. supersonic tunnel. Eight of the models were of the cropped delta type, while the remaining three had a cropped arrow planform. Primarily, the investigation was conducted to assess the effect of aspect ratio on wing characteristics through a systematic variation of the taper ratio.

From author's summary

1782. **Gadd, G. E., Holder, D. W., and Regan, J. D., An experimental investigation of the interaction between shock waves and boundary layers,** *Proc. roy. Soc. Lond.* (*A*) **226,** 1165, 227–253, Nov. 1954.

An account is given of an investigation into the interaction between the boundary layer on a flat plate and a shock wave produced either externally, by a wedge in the supersonic main stream, or from within the boundary layer, by a wedge held in contact with the plate. A wide range of free-stream Mach numbers, boundary-layer Reynolds numbers, and shock strengths has been covered, shock strength being defined as the ratio of the static pressure downstream of the shock to the static pressure upstream of it. Variations in these parameters can have large effects on the interaction, and there are also large differences between cases with externally generated shocks and cases where the shock is generated from within the boundary layer. The investigation has thrown light on the physical mechanisms involved. It is found that many of the major features of the interaction arise because the boundary layer separates from the surface ahead of the shock wave. The conditions under which separation occurs and the behavior of the separated boundary layer thus have important effects, in terms of which, for example, the differences between the interactions observed with laminar and with turbulent boundary layers may be explained.

From authors' summary by W. Bleakney, USA

1783. **Waddell, J. H., and Waddell, Jennie W., Photographic motion analysis,** *Indust. Lab.* **5,** 9, 67–74, Sept. 1954.

©1784. **Coulthard, W. H., Aircraft instrument design,** New York, Pitman Publ. Corp., 1952, viii + 309 pp. $7.50.

Book presents the basic principles on which the design of aircraft instruments depends. Clear treatment of the operation of each instrument and its limitations are discussed. Generous use of charts, diagrams, and cut-away photographs contributes appreciably to the clarity and ease of understanding.

The method of classifying instruments according to their use by crew members—pilot, navigator, flight engineer, and automatic flight instruments—is a convenient and logical sequence of presentation. Among the instruments discussed are those that indicate height, air speed, static and total pressure, rate of change, etc. In addition to the technical material presented, the appendixes contain a list of references and subject index. This book can be recommended to the engineer designing or selecting aircraft instruments. M. Thompson, USA

1785. **Assadourian, A., Operating characteristics of an acceleration restrictor as determined by means of a simulator,** *NACA TN* 3319, 20 pp., Dec. 1954.

The operating characteristics of an acceleration restrictor were determined from tests on a simulator consisting of a control stick geared to a magnetic brake unit and an analog computer. The restrictor worked on the principle of stopping the elevator motion by means of a brake when a signal which was a function of normal acceleration, pitching acceleration, and pitching velocity reached a certain preset value. The results obtained with three brake-operating signals are presented. From author's summary

1786. **Silsby, N. S., Statistical measurements of contact conditions of 478 transport-airplane landings during routine daytime operations,** *NACA TN* 3194, 32 pp., June 1954.

Statistical measurements have been obtained from photographs taken with a specially built motion-picture camera of 478 landings of present-day transport airplanes during routine daylight operations in clear air at the Washington National Airport. From these measurements, sinking speeds, bank angles, rolling velocities, and horizontal speeds have been evaluated and a limited statistical analysis of the results has been made. An attempt was made to determine the effect of various parameters such as gusty-wind conditions, wing loading, and size of airplane (number of engines) which influence the landing contact conditions.

From author's summary

Thermodynamics

(See also Revs. 1669, 1767, 1807, 1817, 1819, 1826, 1827, 1835, 1847)

1787. **van Antwerpen, F. J., editor, Applied thermodynamics (composed of 13 papers),** *Chem. Engng. Progr.* **49,** *Symp. Ser.* no. 7, 1953, iii + 165 pp.; published by Amer. Inst. of Chem. Engrs., New York.

As an aid to discussion the papers may be divided into three categories: phase equilibrium, mixture variables, and thermodynamic properties.

In the phase equilibrium category, DePriester presents distribution coefficients for 33 mixtures of light hydrocarbons from −60 to 300 F. He evaluates correlation methods and presents a series of charts and nomographs useful in design calculations. Hadden develops a theory for hydrocarbon convergence pressures for ternary and complex systems and develops useful methods for rapid design calculations. Schiller and Canjar apply the Benedict-Webb-Rubin equation to the carbon-monoxide-nitrogen system and find good agreement with experimental results. Calculated fugacity coefficients are also tabulated for this system. Canjar and Edmister develop partial enthalpies and entropies for hydrocarbon mixture components in the gaseous and liquid phase from the ideal gas state values and fugacities. They also present a generalized correlation method using reduced condition parameters. Papadopoulos, Pigford, and Friend go back to the original Benedict equation to also calculate these partial molal enthalpies and use a correlation based on the mixture molal average normal boiling point.

Bennett uses nitrogen-ethylene *P-V-T* data to evaluate fugacity prediction methods. Nelson and Holcomb present enthalpy data for the propane, *n*-butane, and *n*-pentane system and use these data for the evaluation of various prediction methods. Tsao

and Smith present heat of mixing data for the methanol, n-heptane, and toluene systems and a method of predicting these data from binary measurements.

The final four papers in the collection are concerned with thermodynamic properties. Michael and Thodos are able to estimate the critical constants of hydrocarbons using a parachor approach. Li and Canjar present P-V-T data for n-pentane in both the liquid and vapor phase. Brydon, Walen, and Canjar present other thermodynamic properties for this material. Finally, Schnaible and Smith tabulate the thermodynamic properties of ethyl ether.

The papers represent a very worth-while contribution to the thermodynamic "tools" needed by the design chemical engineer.

A. Sesonske, USA

1788. Kline, S. J., On the signs in the mathematical expression of the second law of thermodynamics (Brief Note), *J. appl. Mech.* **21,** 4, 408–409, Dec. 1954.

1789. Klein, M. J., and Meijer, P. H. E., Principle of minimum entropy production, *Phys. Rev.* (2) **96,** 2, 250–255, Oct. 1954.

The Prigogine theorem on minimum entropy production is proved by methods of statistical mechanics. A generalization of Pauli's method on the second law of thermodynamics is used to derive the principle of minimum entropy production for a particular irreversible process—the flow of matter and energy through a small capillary connecting two containers of an ideal gas. The paper is divided into four sections. The final section contains a brief discussion of the entropy production in steady state. The steady state corresponds to that set of occupation numbers which minimizes the rate of entropy production.

From authors' summary by Maria Castellani, USA

1790. Reik, H., Thermodynamics of irreversible processes and its application to transport processes. I, II (in German), *Z. Phys.* **137,** 3, 4; 333–361, 463–493, 1954.

In spite of their title, these papers are not only concerned with "irreversible thermodynamics" as commonly understood, but aim at determining the dependence upon time of all thermodynamical quantities during irreversible processes. This is done by laying down a number of equations containing thermodynamical quantities and the time explicitly. From these equations, author claims, relations applying to diffusion and electric conduction (ionic and electronic) are derived.

Reviewer notices that the fundamental equations are formulated in terms of assumptions having only a restricted range of validity; they may, by way of adjustable parameters, be fitted to observational data even if the original assumptions are at fault. Reviewer doubts that these somewhat verbose papers can be used for deriving any result that is not known beforehand.

R. Eisenschitz, England

1791. Kretschmar, G. G., The isothermal compressibilities of some rocket propellant liquids, and the ratios of the two specific heats, *Jet Propulsion* **24,** 3, 175–179, May–June 1954.

The velocity of sound has recently been determined in a number of rocket propellant liquids by means of the ultrasonic interferometer. From these sound velocities and the densities one can compute the adiabatic compressibilities from the acoustical equation $\beta_a = 1/\rho v^2$. If both the adiabatic and the isothermal compressibilities are known, the specific heat ratio may be obtained from the thermodynamic relation $\gamma = \beta_i/\beta_a$. The isothermal compressibilities of a number of liquids have been determined. Data on sound velocities, densities, compressibilities, and specific heat ratios have been worked out for dehydrated gas-free hydrazine for WFNA and for JP-3 and JP-4. The pressure volume data are given in a series of graphs and the results are collected in Table 1. A control run was made on distilled water.

From author's summary

1792. Regener, E., An alternative of the Leidenfrost phenomena (in German), *Z. Naturforsch.* **9a,** 4, 276–278, Apr. 1954.

The most familiar form of the phenomenon described here is the dance of water droplets on a hot plate. The droplets do not immediately evaporate because they are insulated from the hot surface by a boundary layer of poorly conducting vapor.

An arrangement is described for producing an analogous phenomenon with ice. If one leg of an inverted, sealed-off, pyrex U-tube of large diameter containing only water and its vapor is placed in liquid air, the water in both legs quickly freezes; the near side by conduction, the far side by evaporation. The vapor pressure in the tube rapidly falls to extremely low values characteristic of ice at -190 C. The mean free path becomes so large that free molecule flow predominates.

A flame may be applied to the far side without melting the ice. The vapor pressure at the wall-ice interface breaks the ice into small pieces which are thrown violently away from the wall to dance and spin in full view.

The ice dance occurs below the triple point; the water droplet phenomenon above. The tone produced by a piece of solid carbon dioxide pressed against the edge of a metal plate is cited as another example probably occurring above the triple point (-56.6 C and 5.1 atm).

F. D. Bennett, USA

1793. Thomson, W. R., The thermodynamics of frictional resisted adiabatic flow of gases through ducts of constant and varying cross section, *Aero. Res. Counc. Lond. curr. Pap.* 158, 24 pp., 19 figs., Sept. 1952, published 1954.

Report presents an analytical study dealing with the adiabatic flow of gases with frictional losses through ducts of constant and varying cross section. The thermodynamic treatment is along lines published by other workers, such as Bailey and Fabri, and is essentially one-dimensional in character in so far that frictional effects are assumed to be uniformly distributed over the total cross-sectional area of flow. With this simplifying assumption, relationships are deduced connecting the pressure, temperature, velocity, and flow area of the gas at any one plane with those at any other plane in a duct.

The main relationships are unusable for quantitative estimation except through graphs, and the main value of the report lies in the presentation of these graphs, the use of which should facilitate the solution of duct flow problems.

From author's summary

1794. Schiess, J., Elimination of a basic error in the theory of psychrometers (in German), *Ann. Meteor.* **6,** 5/6, 179–185, 1953/1954.

After precise consideration of heat exchange of psychrometer, author gives water-vapor tension at temperature t in the form

$$e = (T/T')[E'B/(B - E') - C_aB(t - t')/\sigma\lambda'] \div [1 + E'/(B - E') + (C_v/\lambda' - C_a/\sigma\lambda')(t - t')]$$

where T(°K) or t(°C) and T'(°K) or t'(°C) are dry and wet temperature, E' saturated water-vapor tension at t', B barometric pressure, σ water-vapor density relative to dry air, C_a and C_v (kcal/kg/°C) specific heats of dry air and water vapor, respectively, at constant pressure, and λ(kcal/kg) latent heat of water at t'. Author confirmed the improved formula using newly developed moisture-testing apparatus and obtained average variations of computed value from the apparatus, one at t = 25 or 40 C within the limits ± 0.2 or $\pm 0.3\%$ relative humidity

with maximum values of ±0.3 to 1.0%. The well-known Sprung's formula will give maximum deviations of 1.7 or 2.0% at the same conditions, respectively. M. Sanuki, Japan

1795. London, A. L., The free-piston-and-turbine compound engine—a cycle analysis, *Trans. ASME* **77,** 2, 197–207, Feb. 1955.

See AMR **7,** Rev. 2571.

1796. Anonymous, Domestic heat pump. Dual purpose unit for water heating and larder cooling, *Engineering* **179,** 4642, p. 47, Jan. 1955.

1797. Bartels, J., Thermodynamics of supercritical pressure steam power plants, ASME Fall Meet., Milwaukee, Wis., Sept. 1954. Pap. 54—F-37, 19 pp.

Paper deals with the efficiencies that are thermodynamically obtainable from a steam power cycle by utilizing throttle pressures exceeding the critical pressure of steam. The analysis starts with Rankine cycles and then successively presents simple cycles, multiple reheat cycles, and increasingly more complex feed-heating arrangements. Thermal efficiencies and heat rates for these cycles are established, and explanations are offered to show why the results turn out the way they do.

From author's summary

1798. Messinger, B. L., and Merrill, W. W., Jr., Compressor bleed in turbine-powered aircraft, *Aero. Engng. Rev.* **13,** 9, 50–62, Sept. 1954.

1799. Heller, L., New possibilities for generating electric power from waste heat (in Hungarian), *Magyar Energiagazdaság* **6,** 2, 34–43, 15 figs., 1953.

Article deals with the exploitation of waste heat which, mainly due to its low power, is not being utilized (low-pressure exhaust steam, hot water, low-temperature flue gases, etc.). New possibilities for the utilization, separately or together, of heat contained in flue gases and hot water are discussed. The proper choice of steam pressure to be applied if flue gases are utilized with steam as a medium (for producing electric power) presents an interesting problem. In this connection the results of computation are useful in themselves and, on the other hand, offer a basis for comparing the methods of utilization dealt with with the classical procedure. As a result of this comparison it can be established that, e.g., the suggested method of flue-gas utilization combined with an absorption heat pump generally obtains a 20 to 30% improvement, depending upon the initial temperature of the gas. Author recommends the utilization of the heat energy of industrial hot water (e.g., the heated cooling water of open-hearth furnaces) and of natural hot-water springs through a system using extremely low pressure but greatly overheated steam, as a further development of the connection proposed by H. Glaser at the Fourth International Heat Energy Congress. A combination of this solution and the afore-mentioned absorption method may yield more than twice the amount of electric power as that obtainable in plants utilizing flue gases in the usual manner, without utilizing the heat contained in the cooling water.

From author's summary

Courtesy of Hungarian Technical Abstracts

1800. Seidner, M., Economical load distribution among steam power plants (in Hungarian), *Magyar Energiagazdaság* **6,** 1, 2; 21–32, 53–61, 16 figs., 18 tabs., 1953.

Loads are economically distributed between parallel operated units on the basis of the well-known differential equation. For solving the equation with mathematical precision, heat consumptions are expressed in the following generally valid equations:

steam boilers,

$$W_x = P_b\left[x + \frac{1-\eta_m}{100\eta_m}\left(40x_m + 20x + \frac{40}{x_m}x^2\right)\right] \text{ kcal per hr}$$

steam turbines,

$$W_x = P_t\left[860x + \frac{w_m - 860}{100}\left(20x_m + 60x + \frac{20}{x_m}x^2\right)\right] \text{ kcal per hr}$$

at load factor x. In these equations P_b is max efficiency, kcal per hr; P_t max efficiency, kw; x = load factor = load: efficiency; η_m optimum efficiency in decimal fractions; w_m optimum heat consumption, kcal per kwhr. Thus the equation expressing incremental load distribution in the case of parallel operated units is

$$\frac{1}{P_1}\cdot\frac{dWx_1}{dx_1} = \frac{1}{P_2}\cdot\frac{dWx_2}{dx_2} = \cdots\cdots\cdots \frac{1}{P_n}\cdot\frac{dWx_n}{dx_n}$$

where indexes 1, 2,. . .n indicate the units. It could be proved by computations based on the above equations that incremental load distribution reduces fuel consumption by 2% as opposed to load distribution by the basic method.

From author's summary

Courtesy of Hungarian Technical Abstracts

1801. Kinkeldei, L., Approximative calculation of storing capacity of a steam accumulator of Ruths' type (in German), *Brennstoff-Warme-Kraft* **6,** 8, 313–314, Aug. 1954.

1802. Rant, Z., Enthalpy diagrams of weak salt solutions *Forsch. Geb. Ing. Wes.* (*B*) **20,** 3, 4 pp., Aug. 1954.

1803. Clark, O. H., Prediction of lubricating-oil viscosities at high pressures, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-39, 7 pp.

Heat and Mass Transfer

(See also Revs. 1537, 1607, 1638, 1642, 1696, 1744, 1790, 1791, 1792, 1796, 1797, 1800, 1806, 1839, 1840, 1847, 1850, 1874, 1878, 1879)

1804. Jain, S. C., and Krishnan, Sir K. S., The distribution of temperature along a thin rod electrically heated in vacuo. Parts II, III, IV, *Proc. roy. Soc. Lond.* (*A*) **225,** 1160, 1–32, Aug. 1954.

Part II. Continuation of article previously reviewed [AMR **7,** Rev. 2607] with same title. Article treats case wherein rod is not too short by combining two particular solutions for similar infinitely long rod heated by same current. The solution so obtained is applicable over the length of the rod. The solution is compared with other formulas proposed. Solution leads in particular to a useful expression for the temperature at the center of a finite but long rod as a function of its length.

Part III. This is a detailed experimental verification of the major theoretical results using Acheson graphite rods electrically heated. Supporting experiments resulting in values of thermal conductivities, electrical conductivities, and spectral and total emissivities, all as functions of temperature, have been conducted satisfactorily.

Part IV. The empirical formulas of Worthing for tungsten wires heated in vacuo are shown to follow naturally as special cases of the theoretical work in parts I and II. Other formulas stated by Worthing are shown in good approximation and the degree of variance is estimated. R. M. Drake, Jr., USA

1805. Khakimov, Kh. R., Heat exchange in a freezing core (in Russian), *Gidrotekh. Stroit.* **22**, 8, 16–19, Aug. 1953.

An experimental investigation was carried out on a natural scale of the heat exchange in a freezing core under the conditions of laminar flow of the heat-carrying liquid. The results agree well with investigations of other Russian workers based on the assumption that heat transfer in the flow should be determined by factors of the free flow as well as of the forced flow.

From simultaneous measurement of the velocity of circulation and of the temperature of the heat-carrying liquid in two different periods during the winter 1952–1953, author obtains a practically important relation between the velocity of circulation and the corresponding change of temperature of the heat carrier (hyperbolic dependence). Further, a linear dependence of the temperature difference on the temperature is established. Finally, it is recommended by the author to keep the velocity of circulation in the freezing core within the limits 4–6 cm/sec instead of 8–20 cm/sec as was hitherto recommended. This is of considerable practical importance.

J. Beránek, Czechoslovakia

1806. Riedel, L., Measurement of heat conductivity (in German), *ATM* no. 228, 15–18, Jan. 1955.

1807. Kowalczyk, L. S., Thermal conductivity and its variability with temperature and pressure, ASME Ann. Meet., New York, Nov. 28–Dec. 3, 1954. Paper 54—A-90, 33 pp.

This paper is a must for the library of the practicing or research engineer who encounters thermal problems in his work. Although your library may well contain the bulk of this information, it is usually scattered and time-consuming to locate. Here is a concise nonmathematical (although over-all quantitative relations are stated) treatment with an extensive domestic and foreign bibliography and lucid figures. The paper is essentially a clear summary of the status of theories regarding thermal conductivity. The variation of thermal conductivity with temperature and pressure is explained by the nature of heat, structure of matter, and resistances offered to heat conduction in various physical states.

C. R. Mischke, USA

1808. Murray, T. B., and Whalley, W. C. R., Temperatures and thermal conductivity of the ground along the alignment of the 30-inch pipeline Kirkuk-Banias in relation to oil temperatures, *J. Inst. Petrol.* **40**, 372, 372–400, Dec. 1954.

Soil temperatures and thermal conductivities were determined at fifty sites along the 556-mile route of the 30-in. pipeline from Kirkuk, N. Iraq, to Banias, Syria. This information was required for oil temperature prediction. Thermal conductivities were derived from the decrement and lag of the annual temperature waves at 2, $4^1/_2$, and $6^1/_2$ ft, obtained by frequent observation of thermometers in closed asbestos tubes. The necessary soil densities and specific heats were found by laboratory measurements on samples. In the method of mixtures for specific heats, aluminum pellets were used as a standard, and inclined rotating calorimeters were used to obtain effective mixing of the two components. Some oil temperature predictions are compared with the corresponding observed values.

Recorded results include: (a) thermal conductivities, specific heats, densities, and monthly average soil temperatures by locations and depths; (b) reproductions of temperature waves by locations and depths.

From authors' summary

1809. Batchelor, G. K., Heat transfer by free convection across a closed cavity between vertical boundaries at different temperatures, *Quart. appl. Math.* **12**, 3, 209–233, Oct. 1954.

The classical equations governing natural-convection flow are examined for limiting values of the prime parameters: Rayleigh number A (product of Prandtl and Grashof numbers) and the ratio of the length of the boundaries to the distance between them l/d. Special consideration is given throughout to the problem of thermal insulation of buildings.

The types of flow to be expected for various ranges of parametric values are discussed and Nusselt numbers are approximated therefrom.

For small A, a power series solution of the equations is indicated and its limitations are discussed. For large A, it is pointed out that a continuous boundary layer forms on the bounding surfaces. Solutions for this case were not obtained because of the difficulty in describing conditions within the core of the cavity. The only explicit solutions presented are those for the fully developed flow, $l/d \rightarrow \infty$.

Evidently the author was unaware of similar research published in this country. In particular, the solution presented for $l/d \rightarrow \infty$ appeared as a special case in the reviewer's treatment of the problem in *NACA TN* 2863 [AMR **6**, Rev. 2357], and the case of A very large in an analogous problem was the subject of the reviewer's dissertation and is described in "Advances in applied mechanics," vol. 3 [AMR **7**, Rev. 2915].

Reviewer feels that the paper presents an excellent integration of the ideas and difficulties which are inherent to the eventual complete solution of an internal natural-convection flow problem. The physical descriptions of the various flow types and the criteria presented for determining the conditions for each type to exist and for laminar flow are also interesting.

Brief consideration is given to approximate Nusselt numbers for turbulent flows, and a comparison of the theoretical heat-transfer predictions with the limited experimental data is made.

S. Ostrach, USA

1810. Sheehan, T. V., Schomer, R. T., and Dwyer, O. E., Heat-transfer rates for crossflow of water through a tube bank at Reynolds numbers up to a million. Part I, ASME Fall Meet., Milwaukee, Wis., Sept. 1954. Pap. 54—F-19, 20 pp.

Paper reports heat-transfer coefficients for two-dimensional flow of high temperature, high pressure water across a tube bundle 10 rows wide and 20 rows deep. Tube diameter (outside) is 0.81 in.; tube spacing is equilateral, with pitch 1.28 in. A total of 29 of the 200 tubes were heated electrically, as many as three simultaneously. Average heat-transfer coefficients for a given tube were computed on the basis of average tube-wall temperature minus entering water temperature, the water-temperature rise as a result of heat addition being negligible. Variation of heat-transfer coefficient with respect to tube location is discussed. Water pressure level was high enough to prevent surface boiling.

Paper is of interest because the scale of the equipment is unusually large for a research investigation and because the Reynolds number range covered (30,000–1,200,000) represents an extension of available data for flow outside tube banks. Heat-transfer coefficients are found to vary as the eight-tenths power of the Reynolds number and to exceed substantially extrapolations of existing correlations based on a variation of the heat-transfer coefficient with the six-tenths power of the Reynolds number.

J. L. Mason, USA

1811. Dwyer, O. E., Sheehan, T. V., and Weisman, J., Heat-transfer rates for crossflow of water through a tube bank at Reynolds numbers up to a million. Part 2, Circumferential variation of film coefficient for individual tubes, ASME Fall Meet., Milwaukee, Wis., Sept. 1954. Pap. 54—F-20, 13 pp.

Paper reports circumferential variation of heat-transfer coefficient for two-dimensional flow of high temperature, high pressure water across a tube bundle 10 rows wide and 20 rows deep. Tube

diameter (outside) is 0.81 in.; tube spacing is equilateral, with pitch 1.28 in. Variation between average and extremal values of the heat-transfer coefficient was found to be of the order of 15–20%, which is much less than variations reported elsewhere for flow of air. Tube walls were electrically heated, the tube surface being used as the heating element. Heat generation within the tube was substantially uniform, and circumferential flow of heat negligible. Novel instrumentation was devised to obtain circumferential tube-wall temperature distributions. Results were compared for different tube locations; all tubes except those in the first row showed approximately the same profiles of coefficient versus circumferential position. Anomalous results with tubes in the first row are attributed to the absence of turbulence on the front half of the first row. J. L. Mason, USA

1812. **Dwyer, O. E., Horn, F. L., and Weisman, J., Heat-transfer rates for crossflow of water through a tube bank at Reynolds numbers up to a million. Part 3, Forced-convection boiling and pressure drop data,** ASME Fall Meet., Milwaukee, Wis., Sept. 1954. Pap. 54—F-21, 16 pp.

Experimental data are presented for forced convection (surface) boiling of water flowing past a tube bundle. A review of the nature of surface boiling is presented. Data are insufficient to give quantitative support to previously suggested correlations, but are useful in view of the scarcity of any data at all in this field. Main conclusions are that large increases in the average film coefficient over ordinary forced convection may be obtained by operation in the surface boiling regime; that the superheat required to initiate surface boiling is not greatly influenced by changes in operating variables (being of the order of 20 to 30 deg F); and that the heat-transfer rate from a given tube during surface boiling is not appreciably influenced by surface boiling on adjacent tubes. J. L. Mason, USA

1813. **Burke, E., and Kemeny, G. A., A novel cooling method for gas turbines,** *Trans. ASME* **77**, 2, 187–194, Feb. 1955.

See AMR **7**, Rev. 2298.

1814. **Steinbacher, F. R., and Young, L., Problems in the design of aircraft subjected to high temperatures,** Symposium on the Thermal Barrier, ASME Ann. Meet., New York, Nov. 28–Dec. 3, 1954. Paper 54—A-100, 7 pp.

Paper discusses aerodynamic heating, material considerations, creep, fatigue, material stability, low thermal expansion alloys as weight savers, and the need for a new criterion of structural safety. The text is nonmathematical and supported by numerous curves and charts illustrating points made in the course of discussion. The decreasing importance of fatigue with increasing temperature is brought out. A reappraisal of the current 1.5 factor of safety used by the aircraft industry is urged. The displacement of aluminum in favor of another aircraft structural material is foreseen. The sterility of alloying elements at temperatures above 2000 F is noted. C. R. Mischke, USA

1815. **Oppenheim, A. K., Radiation analysis by the network method,** ASME Ann. Meet., New York, N. Y., Dec. 1954. Pap. 54—A-75, 22 pp.

A general procedure is developed to represent the radiation exchange in an enclosure of arbitrary shape by means of electric-circuit models. The enclosure may consist of any number of gray heat-transfer surfaces and may be filled with any number of unmixed gray gases. However, the analysis is restricted to diffuse radiation within the enclosure. All interreflections of radiation beams are taken into account by conductances that are simple functions of surface-shape factors, reflectivities, and transmissivities. Because the conductances are not coupled magnetically, the composite network of the entire system is ideally suited to be solved in easy stages by being torn apart into several isolated networks and inverted piece by piece. The component inverse matrixes may then be interconnected to form the solution of the entire system. Any fractional portions of the external flux vectors, of the emissive powers and radiosities may be assumed afterward as known quantities.

The paper gives an example on how to set up systematically by tensorial methods the equations of either the entire system or of one subdivision only. When the emissivity depends on gas temperature, the resulting nonlinear network leads to more rapid convergence if the piecewise established, though approximate, inverse matrixes are iterated upon in succession. The paper generalizes the method to systems with combined energy transfer, such as a combustion chamber, by interconnecting three types of networks that represent combustion, convection, and radiation energy transfers, respectively. G. Kron, USA

1816. **Topper, L., Radiant heat transfer from flames in a turbojet combustor,** *Indust. Engng. Chem.* **46**, 12, 2551–2558, Dec. 1954.

The problem of combustor wall cooling in jet-propulsion engines is of prime importance, and thus information on rate of energy transfer from flames is of fundamental interest. Using a total-radiation pyrometer to measure the equivalent black-body temperature of the flame and a disappearing-filament optical pyrometer to measure the red-brightness temperature, author employs a method based on the two-color principle to calculate average flame temperatures and emissivities.

From data so calculated author concludes that, in a turbojet combustor: (1) intensity of radiation from flame increased rapidly with an increase in combustor inlet pressure and, to a lesser degree, was affected by variations in fuel-air ratio and air mass flow; (2) total radiation of the luminous flames (containing incandescent soot particles) was greater (4 to 20 times) than the molecular nonluminous radiation due to carbon dioxide and water vapor; (3) measurable radiant energy is in the primary combustor zone only and in this region the greater part of the total energy transfer to the liner may consist of radiation from the flame; (4) flame emissivities were from 0.09 to 0.79.

I. Glassman, USA

1817. **Ross, W. D., Methods of representing radiation formulas,** *J. opt. Soc. Amer.* **44**, 10, 770–771, Oct. 1954.

Three methods are discussed for representing spectral distribution of radiation intensity. They are based on equal increments of wave length, of wave number, or of logarithmic units (wave length or wave number). The three methods show maxima at different wave lengths. The most clearly descriptive type of plot shows the cumulative energy up to a given wave length against the logarithm of wave length. The author suggests that the Wien maximum should be de-emphasized. Radiation slide rules by General Electric Co. and A. G. Thornton, Ltd. (according to British Admiralty Research Laboratory) are recommended.

W. M. Conn, USA

1818. **Collins, W. I., Small and medium size cyclone furnace boilers,** ASME-AIME Ann. Fuels Conf., Pittsburgh, Pa., Oct. 1954. Pap. 54—FU-3, 16 pp.

1819. **Ingebo, R. D., Vaporization rates and drag coefficients for isooctane sprays in turbulent air streams,** *NACA TN* 3265, 39 pp., Oct. 1954.

Drop-size distribution and drop-velocity data were obtained for isooctane sprays in turbulent air streams using a droplet camera

developed at the NACA Lewis laboratory. Experimental spray vaporization rates, based on the mean diameter, correlated single-droplet vaporization rates. An empirical expression was derived for isooctane droplet drag coefficients.

From author's summary

1820. Jens, W. H., Boiling heat transfer: What is known about it, *Mech. Engng., N. Y.* **76,** 12, 981–986, Dec. 1954.

Paper attempts to answer questions: Why is a large research effort necessary? Why is it so expensive to obtain fundamental boiling data? What progress has been made in the study of boiling?

From author's summary

1821. Lype, E. F., Kinetic theory of evaporation rates of liquids, *Trans. ASME* **77,** 2, 211–219, Feb. 1955.

See AMR **7,** Rev. 3340.

1822. Styrikovich, M. A., and Shitsman, M. E., New data on the temperature variation of boiler tubes at very high pressures (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **96,** 1, 69–72, May 1954.

Authors report on heat-transfer experiments with a vertical boiler tube with natural circulation. Although the parameters governing boiler-tube circulation are not fully understood, valuable information for design at very high pressures has been obtained. It has been assumed erroneously in the past that wall temperatures of boiler tubes only increase above the permissible limit if either the tubes are full of vapor or when circulation is suppressed or reversed. Experiments show that with normal rates of circulation at high pressures, excessive tube-wall temperatures may be obtained even if the dryness fraction of the steam in the tubes is well below unity.

Experimental ranges covered by the authors are: Pressure, 2590–2974 lb/in.^{2}; specific heat flow, 85,000–265,000 Btu/ft^2 hr; circulation velocity, 0.7–7.2 fps; circulation mass velocity, 44,000–295,000 lb/ft^2 hr; dryness fraction, 0.08–1.

Y. R. Mayhew, England

1823. Schwarz, K., Investigation of the density distribution, the water and steam velocities, and the friction losses in vertical and horizontal boiler tubes (in German), *VDI-Forschungsheft (B)* **20,** 445, 44 pp., 1954.

Article represents an abbreviated edition of author's dissertation dealing with the flow phenomena inside the tubes of a boiler with natural circulation. The results were obtained on a full-scale model of the boiler, with special emphasis placed on the distribution of the water and steam over a cross section of a boiler tube. The boiler pressures were varied from 300 to 1200 psi approximately.

The plots of the absolute and relative velocities of steam and water for various pressures and for different mean densities of the mixture are presented for horizontal and for vertical boiler tubes. The mean density distribution across the tube diameter for various pressures, as well as the relationship of the steam and water velocities versus weight flow, are shown for vertical and horizontal boiler tubes. The friction losses for different mixture velocities and for various steam and water flows are included.

It was shown that, for vertical tubes, the profiles of the density distribution are symmetrical, with the lowest density along the tube axis and with the inner tube walls covered with a water layer. In horizontal tubes, however, a separation of water and steam takes place, so that the upper portion of the tube cross sections was entirely filled by steam after a very short horizontal run. In this case, overheating of risers may result.

For higher density of the mixture (lower evaporation), with increasing pressures, the relative velocity of steam in regard to water is considerably smaller than in a stationary water column. For a lower density of mixture, the relative steam velocity increases considerably above the values observed in a stationary water column.

The mean velocities observed in a horizontal position of the riser show that the steam travels at a considerably higher velocity than the water, provided that the steam was separated from the water and occupies an appreciable portion of the cross-sectional area.

The friction coefficient for water-steam mixture was found to be essentially higher than currently employed values for homogeneous media.

This investigation shows a new scientific approach to a problem of great importance to the designer of natural-circulation boilers. The instrumentation employed during this investigation for the measurement of weight flow represents a combination of mechanical and electronic arrangements.

D. Kurtovich, USA

1824. Baker, L., The synthesis of two marine water-tube boilers, *Instn. mech. Engrs. Proc.* **168,** 4, 135–146, 1954.

Paper gives a brief résumé of the important lessons learned from the operations of oil-fired water-tube boilers at sea since 1925. These are linked with the shipowners' requirements—particularly those pertaining to the postwar merchant service—and the development of two designs of boiler from these requirements is shown. In this way it is possible to accept fundamentally different designs of boiler for application in the same ship.

From author's summary

1825. Siegert, A. J. F., On the theory of condensation, *Phys. Rev.* (2) **96,** 2, 243–249, Oct. 1954.

Paper is an attempt to understand why approximations of the van der Waals type can yield semiquantitative results, in spite of being qualitatively wrong. The author has considered as a model of a real fluid, a cubic array of submacroscopic cells with variable numbers of particles, assuming an interaction energy between adjacent cells only. This model exhibits condensation. Its condensation pressure, its isotherm in the stable states, and its critical temperature are still essentially determined by those of the individual cells.

From author's summary by Maria Castellani, USA

⊗1826. Hougen, O. A., Watson, K. M., and Ragatz, R. A., Chemical process principles. Part I. Material and energy balances, 2nd ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, xxv + 504 pp. $8.50.

This new edition of Vol. I of "Chemical process principles" contains several improvements over the old volume. Some of the material has been reorganized and supplemented, and two new chapters have been added. These include a brief treatment of mathematical procedures used in chemical engineering, and a chapter on adsorption. The discussion of ternary liquid mixtures has been amplified, sections on solvent extraction and nuclear reactions have been added, and the thermochemical data have been brought up to date. A new correlation between critical constants and molecular structure recently developed by other workers has been included. Many new problems might have been desirable.

A. W. Gessner, Germany

1827. Jaswon, M. A., and Smith, W., Countercurrent transfer processes in the non-steady state, *Proc. roy. Soc. Lond. (A)* **225,** 1161, 226–244, Aug. 1954.

The behavior of countercurrent transfer-process systems is analyzed mathematically to develop relations between concentrations or temperatures, time and position under transient con-

ditions. A solution is obtained as a power series in modified Bessel functions. A linear relation between the equilibrium values of concentration in each phase was assumed. It is also assumed that flow rates of each phase holdup per unit of transfer area and transfer coefficients are constant throughout the system. Applications of the derived equations to a heat exchanger and a batch distillation column are illustrated by examples. In the case of a heat exchanger, the equations are used to predict the temperature of each stream as a function of position and time following an instantaneous change in the inlet temperature of one stream. Concentrations of each phase in a batch distillation column are predicted as a function of position and time following an instantaneous change in reflux ratio.

T. J. Connolly, USA

1828. Goldsmid, H. J., and Douglas, R. W., The use of semiconductors in thermoelectric refrigeration, *Brit. J. appl. Phys.* 5, 11, 386–390, Nov. 1954.

In the past, the possibility of thermoelectric refrigeration has been considered, but all attempts to produce a practical refrigerator have failed owing to lack of suitable thermocouple materials. In this paper it is proposed that semiconductors should be used and the factors governing their selection are discussed. It is concluded that the semiconductors should be chosen with high mean atomic weights and that they should be prepared with thermoelectric powers lying between 200 and 300 $\mu V\,°C^{-1}$. Preliminary experiments have led to the production of a thermocouple consisting of bismuth telluride, Bi_2Te_3, and bismuth, capable of maintaining 20 C of cooling.

From authors' summary

1829. Potter, R. D., Calibration of a nickel-molybdenum thermocouple, *J. appl. Phys.* **25**, 11, 1383–1384, Nov. 1954.

1830. Mijnheer, A. B., Errors in measuring static temperatures (in Dutch), *Ingenieur* **67**, 1, 0.12–0.14, Jan. 1955.

1831. Van Dijk, S. F., The verification of thermometers (in Dutch), *Ingenieur* **67**, 1, 0.9–0.12, Jan. 1955.

1832. Turbine-blade temperature telemeter, *Instrum. Automat.* 27, 12, 1958–1959, Dec. 1954.

Inductive commutator permits measurement of temperatures of turbine blades rotating at 25,000 rpm. From summary

Combustion

(See also Revs. 1815, 1816, 1826)

1833. Ghosh, B., and Orning, A. A., Igniting pulverized coal, *Indust. Engng. Chem.* **47**, 1, 117–121, Jan. 1955.

To study the influence of different factors upon the ignition process of pulverized coal, small flames were produced in an electrically heated furnace (4 × 4 × 1.5 in.) which provided the required heat by two 0.5-in. Globars. Time of ignition was found to decrease with concentration of coal in air. Sonic energy has a retarding effect. Rank of coal influences the allowable excess air and the required temperature, high-vol. coal igniting more readily than low-vol. coal. Increasing fineness of coal shortens ignition time with but little difference between medium (50 μ) and smallest (6 μ) particles. Furnace atmosphere had little influence because of limited mixing effect, but O_2 enrichment in the primary air/coal stream accelerated ignition considerably. Nusselt and Traustel's theories are substantiated in principle. Effect of vol. matter is lower than indicated by previous curves of de Grey.

W. Gumz, Germany

1834. Jackson, J. L., Brokaw, R. S., Weast, R. C., and Gerstein, M., Flow apparatus for determination of spontaneous ignition delays, *Indust. Engng. Chem.* **46**, 12, 2547–2550, Dec. 1954.

Primarily a report of a new apparatus, but data on propane-air mixtures are included. The essential difference from the work of Mullins and others is in the use of a homogeneous flow system. Fuel and air are preheated separately, then mixed at desired temperature and constant pressure in a time relatively short as compared to ignition lags (0.1 sec or more in these experiments). The diameter of the reaction tube had no effect within range of 25–50 mm, but there is an optimum rate of flow which varies with composition.

In contrast to quenching distances and minimum spark ignition energies, ignition lag decreases steadily as fuel concentration is increased. In agreement with this, quite different results were obtained, depending upon whether fuel or air was introduced first. In the latter case, flame fronts was often indistinct. Increased temperature decreased ignition lag.

R. C. Anderson, USA

1835. Mullins, B. P., Ignition delay measurements on gas turbine fuels by the N. G. T. E. method, *Ingenieur* **66**, 36, 57–61, Sept. 1954.

A survey on the problem of ignition and combustion of liquid fuels, both for a single droplet and for a shower.

From author's summary

1836. Loison, R., and Giltaire, M., Ignition of gaseous mixtures by fracture of membranes under pressures (in French), *Mém. Artill. fr.* 128, 4, 949–971, 1954.

Experimental results are reported for stoichiometric mixtures of methane-oxygen, butane-oxygen, and hydrogen-oxygen, which were ignited by the rupture of a diaphragm. The apparatus was a conventional shock tube, arranged so that chemical and photographic observations could be made. Air and inert gases were used in the pressure chamber, with the combustible mixture in the open section of the tube, at atmospheric pressure. It was found that when ignition occurred, it took place in the neighborhood of the diaphragm.

Authors point out that the temperature produced across the plane shock wave from the apparatus is substantially lower than that required to ignite the mixture by adiabatic compression. They suggest that ignition may be caused by the interference and reflection of spherical shock waves immediately following the diaphragm breakup, which could produce local transient pressures of sufficient magnitude to reach the ignition temperature.

J. S. Arnold, USA

1837. Dugger, G. L., Flame stability of preheated propane-air mixtures, *Indust. Engng. Chem.* **47**, 1, 109–114, Jan. 1955.

Flash-back and blowoff data for propane-air flames burning from a 1.56-cm tube are reported for initial mixture temperatures of 306, 422, 506, and 617 K. Stream flow Reynolds numbers varied from 240 to 7400. Data are presented in terms of average stream velocity, critical stream flow Reynolds number, critical boundary velocity gradient, and penetration distance (flame velocity/critical boundary velocity gradient). Some typical empirical equations for critical average stream velocities as functions of temperature are given.

A comparison between calculated penetration distances d_p and quenching distances d_o from the literature showed that d_o is more than double $2\,d_p$. Reviewer believes that a more proper comparison would be given by $d_o = 2\,d_p + 2r_{\min}$, where $r_{\min}$ is the radius of the smallest sphere of gas which must be ignited to

insure self-propagation of a flame. This value may be calculated from minimum spark-ignition energy data.

The theoretical treatment of Grumer and Harris for flash back, modified by using the Semenov equation for burning velocity, is shown to give satisfactory prediction of critical boundary velocity gradients. M. F. Hoare, England

1838. Van Wonterghem, J., and Van Tiggelen, A., Thickness and propagation velocity of a flame front (in French), *Bull. Soc. Chim. Belges* **63,** 235–260, May 1954.

Flame propagation velocities, flame temperatures, and distances between visual and schlieren cone have been measured for acetylene, ethylene, and carbon monoxide mixture with air or oxygen. It is shown that the classical measurements of flow rate and flame surface, in order to calculate the burning velocity, may be replaced advantageously by the measurement of flame temperature and distance between visual and schlieren cone. A theoretical relationship has been derived between the three measured quantities. From authors' summary

1839. McHugh, B., Investigation of flame radiation in oil firing (in Swedish), *Tekn. Tidskr.* **84,** 42, 1001–1006, Nov. 1954.

Investigation carried out under the sponsorship of Flame Radiation Research Joint Committee (representatives from France, Holland, Great Britain, and Sweden) was supposed to produce information about the visible part of the total radiation from flames in industrial furnaces.

Experiments were made in a vertical cylindrical furnace of 2-ft diam and 16-ft height, with water-cooled walls. The heat transfer to the walls, flame radiation, flame emissivity, and flame temperature were measured over the length of the furnace Effect of the air-fuel ratio, rate of atomization, air preheating, and fuel supply was studied.

Any important influence of the parameters mentioned has not been revealed. Results are compared with data obtained from experiments on a furnace in Holland with uncooled walls. It is found that the main effect of the wall temperature is a more compact flame with higher emission in the case of the cooled wall. C. E. Lenngren, Sweden

1840. Thring, M. W., Combustion and radiation characteristics of oil and coke-oven gas jet flames, *Engineer, Lond.* **198,** 5150, 499–501, Oct. 1954.

This is one of Prof. Thring's most concise papers on this topic, combining some of the good results obtained from open-hearth furnaces, cold models, and the Ijmuiden experimental furnace.

Paper discusses the factors influencing fuel consumption in melting, the balance between roof temperature limits and heat-transfer coefficient between flame and charge, and also the fact that there is an optimum flame length for each stage of melting. Paper further shows the influence of various input variables of the Ijmuiden furnace (equivalent nozzle diameter, excess air, atomizer, air- and fuel-preheat, and fuel character) on flame characteristics (length, temperature at beginning and end of flame, emissivity at beginning and end). M. A. Saleh, Egypt

1841. Kuhns, P. W., Determination of flame temperatures from 2000° to 3000° K by microwave absorption, *NACA TN* 3254, 48 pp., Aug. 1954.

Microwaves of 27,600 megacycles and, in some experiments, 9650 megacycles, were used to measure both steady and rapidly fluctuating flame temperatures. The method is based on addition of an alkali salt to the fuel; the electrons formed by thermal ionization attenuate the microwave beam. A theory permitting calculation of the flame temperature from the measured attenuation is developed, which requires knowledge also of the effective ionization potential of the alkali metal and the free electron collision frequency. Therefore these quantities were measured in experimental flames. The alkali metals Cs(4.30 e.v.), Rb (4.37 e.v.), K(4.54 e.v.), and Na(5.15 e.v.) were studied. The effective ionization potential for Na agreed closely with the spectroscopic value. The electron collision frequency was found to be 1.9 × 10 fps at 2200 K. Using the above values, an accuracy of ±60 K in the flame temperature measurement was obtained. Changes of temperature of ±5 K could be detected.

This paper is an interesting extension of an approach first developed by T. M. Sugden and co-workers [*Trans. Faraday Soc.* **44,** 427, 1948, and *Proc. roy. Soc.* (*A*) **201,** 480, 1950 and (*A*) 202, 17, 1950]. R. Friedman, USA

1842. Gaydon, A. G., and Wolfhard, H. G., Comparison of the spectra of turbulent and laminar flames, *Fuel* **33,** 3, 286–290, July 1954.

Premixed flames with natural turbulence show qualitatively the same spectra as laminar flames, but quantitative measurements have not been possible. Premixed flames of ethylene and air with induced turbulence, using a grid, show a reduction in radiation of C_2, CH, OH, and HCO of about 20% under the conditions used; this may be due to quenching of fragments of the flame front when it is broken up by turbulence. With diffusion flames, decreasing carbon formation and increasing C_2 and CH radiation with increasing turbulence are attributed to air entrainment. From authors' summary

1843. Kinbara, T., and Nakamura, J., On the ions in diffusion flames, *Sci. Pap. College Gen. Education, Univ. Tokyo* 4, 1, 9–19, July 1954.

1844. Whitney, L. M., Exhaust-gas sampling of a small-scale combustor, and determination of combustion efficiency, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-61, 12 pp.

1845. Garner, F. H., and Henny, V. E., Performance differences in fuels burnt at reduced pressures, *Fuel* **33,** 3, 311–315, July 1954.

Performance characteristics of a number of pure hydrocarbon fuels have been studied in a small combustion rig at reduced pressures. The fuels tested included benzene, toluene, methycyclohexane, *n*-neptane, isooctane, and three gases—propane, propylene, and isobutane. While the reduced pressure has no effect on the relative order of the maximum flame temperature of the gases, it does have a pronounced influence for liquid hydrocarbons. Thus at the higher altitudes corresponding to low pressure, physical characteristics and also the molecular structure of the fuel appear to be of importance. From authors' summary

1846. Bowen, I. G., and Tipler, W., The choice between single and multi-combustion systems for gas turbines, *N.E. Cst. Instn. Engrs. Ship. Trans.* **71,** 4, 99–112, Feb. 1955.

1847. Kobe, K. A., and Hall, R. N., Jr., Heating of water by submerged combustion, *Univ. Texas Circ.* no. 24, 16 pp., June 1954.

Senior author, in six previous papers, has evaluated submerged combustion technique, i.e., heating of a liquid by direct contact with a flame maintained beneath its surface, for evaporating or dewatering industrially important solutions and suspensions.

Present paper extends coverage to direct-contact heating of water. Commercial 250,000 Btu/hr submerged combustion burner in 550-gal tank was fed with natural gas (91% CH_4) and

air at 2 psig, mixed in the burner and ignited by independent pilot. Tank was topped with packed-column condenser and spray dehumidifier to preheat feed water while reducing exit vapor temperature to within 15–20 F of inlet water. Equilibrium operating temperature of exit water was 188 F vs. theoretical 192° by Dalton's Partial Pressure Law. Over-all water-heating efficiency was 90%, could probably be raised to 95% by insulation of tank. Corrosion rate of submerged steel specimens was twice that of steel in unagitated water of same temperature and CO_2 and O_2 content. Envisioned commercial applications include laundry-water and boiler feedwater heating.

P. W. Jensen, USA

1848. **Street, J. C., and Thomas, A., Carbon formation in pre-mixed flames,** *Fuel* **34,** 1, 4–36, Jan. 1955.

The critical concentration of air required to suppress carbon formation in premixed flames at constant pressure has been determined for a large number of fuels by the use of a Bunsen-type burner from which secondary air was excluded. Fuels of low vapor pressure were burned as mists. The effects of varying the oxygen concentration in the air supply, preheating the unburned gases, and adding small quantities of other substances to the unburned mixture have also been studied. The recent literature on the chemical mechanism of carbon formation is reviewed, and current theories are compared. It is suggested that carbon forms in premixed flames in much the same manner as in diffusion flames, but that oxygen, by combination with carbon atoms, prevents those atoms from participating in the process.

From authors' summary

1849. **Knox, J. H., and Norrish, R. G. W., Cool flame phenomena in the oxidation of ethane,** *Trans. Faraday Soc.* **50,** part 9, 928–933, Sept. 1954.

The development of a thermal theory for the periodic nature of the cool flame phenomena, as a result of work on the oxidation of higher hydrocarbons, has led to a reinvestigation of the oxidation of ethane. Experiment has shown that there exists a well-defined "negative temperature coefficient" in the rate of the slow oxidation of ethane between 350 and 410 C. In addition, it is shown that cool flames can be obtained in sufficiently large reaction vessels between 300 and 380 C at pressures of 600-mm Hg upward with ethane + oxygen compositions ranging from 32/1 to 3/2.

From authors' summary

1850. **De Graaf, J. E., Flames: Their combustion and radiation,** *Ingenieur* **66,** 36, 61–69, Sept. 1954.

Scientific aspects. Soot formation has been studied in hydrocarbon flames (particularly oil flames) and in preheated nonburning streams of propane. The carbon in the large flames seems to be coarser than that in small flames. Soot concentrations have been determined approximately. Thermal cracking of propane gives easily a much higher specific emissivity than the soot formation in oil flames, the main reason being a very short time for soot formation in flames.

The aerodynamics of flames has shown that a flame is in many respects very similar to a jet, although differences in detail exist and may prove to have influence. The solid angle of a burning jet is definitely larger than that of a free jet. The flames investigated so far have shown rather important recirculation, the influence of which on combustion, soot formation, and radiation still remains to be evaluated. At least for part of this work model investigations will be valuable; here the similarity criteria remain to be investigated experimentally and theoretically.

Practical results. Influences of type of fuel (oil, pitch-creosote, coke-oven gas, etc.), type of atomizing agent (air or steam), quantity of combustible and of combustion air, type of burner, etc., were studied. Practical experience with these variables was confirmed and quantitatively evaluated. One exception, the influence of quantity of atomizing agent, is a reason for further investigations. In other cases, questions which arose but which were not answered in works practice, were more or less settled, as in the case of types of oil burners where differences proved to be much smaller than usually supposed. In studying carburetted gas flames, it was found that, in big flames, some 20% of the calorific input can be gas instead of oil without noticeable loss of radiation from the flame. The type of hydrocarbon used proved to be important, and in particular its carbon-hydrogen ratio, rather than, e.g., molecular weight.

From author's summary

Acoustics

(See also Rev. 1694)

1851. **Gavreau, V., and Miane, M., Electrodynamic ultrasonic sources made of solids vibrating in resonance** (in French), *Acustica* **4,** 3, 387–395, 1954.

Paper discusses electrodynamic ultrasonic sources made of solids vibrating in resonance; advantages of this type for acoustic measurements; possibility of obtaining large acoustic power from them; focusing; regenerative systems for high frequencies; methods of making the ultrasonic vibrations visible; study of the vibration of the emitting surfaces; audibility of high-frequency sounds; application to the absolute calibration of microphones at ultrasonic frequencies.

From authors' summary by W. P. Mason, USA

1852. **Takahasi, T., Vibrations of air column having variable cross-section,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 567–569.

Neglecting flow variations over the cross section, a formal solution to quasi-one-dimensional wave equation for title problem is constructed as an expansion in powers of (unknown) natural frequency. The determination of this frequency for various end conditions is briefly discussed.

J. W. Miles, USA

1853. **Tamm, K., and Kurtze, G., assisted by Kaiser, R., Measurements of sound absorption in aqueous solutions of electrolytes,** *Acustica* **4,** 3, 380–386, 1954.

1854. **Beyer, R. T., Formulas for sound velocity in sea water,** *J. mar. Res.* **13,** 1, 113–121, 1954.

Recent measurements by Del Grosso show a discrepancy between computed and observed values of sound velocity in sea water. The basis of Kuwahara's formula has been re-examined. The chief cause of the discrepancy lies in the use of a value for the compressibility of pure water that is too large.

From author's summary

1855. **Miles, J. W., On nonspecular reflection at a rough surface,** *J. acoust. Soc. Amer.* **26,** 2, 191–199, Mar. 1954.

The problem considered is the reflection of a plane scalar wave at a rough surface separating two fluid media, in the approximation of "small roughness." That is, the deviation ζ from planarity is much less than λ, the wave length of the incident radiation, and the surface is slowly varying.

The method consists of obtaining approximate boundary conditions at the surface $z = \zeta(x,y)$ by neglecting second-order terms in ζ and the derivatives ζ_x and ζ_y of ζ, and applying these at the surface $z = 0$.

The important results are, as stated in the author's summary:

"Exact solutions are obtained when the roughness is harmonic, while asymptotic results are obtained for arbitrary distributions. The analysis deals principally with an incident wave that is harmonic in time, but the problem of the reflection of a pulse from a perfectly reflecting, sinusoidal boundary is solved. It is found that such a boundary acts as a band-pass filter of the nonspecular components of the reflected wave. Outside of this pass band the reflection is not only specular but distortionless. Rather less generality is possible when the boundary is not perfectly reflecting, but the pass band is found to be independent of the properties of the reflecting medium."

Reviewer believes the results to be correct with the following reservation: Referring to solutions, Eqs. (3.9) and (5.6), small changes on the roughness characteristics introduce disproportionate changes in the behavior of these solutions. There are also numerous typographical errors. K. M. Siegel, USA

1856. Parkin, P. H., and Purkis, H. J., Noise levels underneath some civilian aircraft shortly after take-off, *Acustica* **4,** 4, 439–440, 1954.

The maximum sound pressure levels (in octave bands) have been measured underneath several types of civilian aircraft shortly after take-off. The height of the aircraft varied from 15–90 m; the results have been corrected to a standard height of 38 m. From authors' summary

1857. Lippert, W. K. R., A new method of computing acoustical filters, *Acustica* **4,** 4, 411–420, 1954.

A new method of computing the sound reflection and transmission of acoustical filters which does not depend on the image parameter theory is presented. The transmitted and reflected sound pressure propagating along a duct with n equal filter sections connected in cascade is represented by the characteristic factors of one section which consists of a so-called symmetrical discontinuity with a duct piece of arbitrary length connected to the input and output. In loss-free cases the sound transmission and reflection can be found with the aid of diagrams. It is shown how the new method differs from the image parameter theory and that it is superior in cases of a small number of practically loss-free filter sections which are terminated by a nonreflecting duct system. The sound reflection and transmission of a filter with a reflecting output duct can be easily derived from the fundamental case with a nonreflecting terminal, and this method can also be applied to filters that are terminated by nonequal sections. From author's summary

1858. Bergassoli, A., Canac, F., and Vogel, T., The acoustical insulation of spherical shells (in French), *Acustica* **4,** 4, 403–406, 1954.

The acoustical insulation of spherical shells has been found to be appreciably greater than that of plane disks in the lower frequency range. This result is accounted for in a theoretical discussion of the natural frequencies of the shell, under the assumption of extensional vibrations. From authors' summary

1859. Vakhnin, V. M., Characteristic functions of real resonators (in Russian), Nat. Sci. Found. tr-166, Jan. 1954; *Dokladí Akad. Nauk SSSR* (*N.S.*) **91,** 4, 779–782, Aug. 1953.

1860. Gershman, S. G., Interference method of measuring correlation coefficients of stationary noises (in Russian), Nat. Sci. Found. tr-157, Jan. 1954; *Dokladí Akad. Nauk SSSR* (*N.S.*) **92,** 1, 33–35, Sept. 1953.

Ballistics, Detonics (Explosions)

1861. Yamaga, N., A new solution of the interior ballistics of guns, *J. indust. Explos. Soc. Japan* **15,** 93–104, June 1954.

Author has derived an exact solution of the Charbonnier-Sugot's equation of interior ballistics without abbreviating any of the terms, and carried out sample calculations with cordite and tubite. The results show general tendency of higher maximum pressure and lower initial velocity than values obtained from simple solutions. T. Hikita, Japan

1862. Crocco, G. A., Some problems of geodetic missiles (in Italian), *Aerotecnica* **34,** 2, 59–71, Apr. 1954.

Author recalls the modern tendency to increase flight speeds, and takes into consideration the employment of so-called geodetic missiles.

The rocket is defined as a "mechanical device for which the support necessary for the motion is completely developed by a 'load' stored on the rocket." In connection with the use of missiles for civil and military purposes, author describes the principles of rocket operation and the feature of geodetic missiles trajectories. The most important problems connected with the employment of geodetic missiles are also discussed. They are: (a) The rise of temperature of rocket during its return to earth surface; the author calculates theoretically the law of motion to be followed in order to keep such temperature within acceptable limits. Further devices (heat suction from boundary layer) are also proposed. (b) The so-called levilation, i.e., absence of acceleration in the central part of the trajectory; the author deems that this circumstance is not noxious for the human body, but might influence the rocket instruments. Gyroscopic instruments are recommended. (c) The use of orbital stations for military purposes. (d) The convenience of using nuclear power for such missiles.

Finally, the ratio of specific power to maximum speed is analyzed with reference to Gabrielli-von Kármán's diagram. Author's theoretical researches show: (a) Thermochemical missiles are represented, on the diagram, by points that lie far away from the ideal optimum straight line of such diagram; the specific power increases about as the power 3.5 of maximum speed. (b) For thermonuclear missiles the specific power increases with a power of speed less than 1. The points representing them are on a line that crosses the ideal straight line. P. Santini, Italy

1863. Garnier, M., Modern exterior ballistics in France (in French), *Mém. Artill. fr.* **28,** 117–234, 1954.

This is an authoritative exposition of exterior ballistic methods in France, with a review of the progress made since Bernoulli and Euler. In World War I, under urging from Charbonnier, the author, with Haag and Marcus, introduced the G-H-M-1917 method of short arcs. Later advances have consisted chiefly of revisions in the formulas for air density aloft, the use of Mach numbers, adoption of curvilinear coordinates, with local geodesic altitude and mean sea level as zero elevation, acceptance of variation of gravitational acceleration with altitude. This exposition covers the most recent revision, the G-H-M-1953 method. Computation sheets are laid out with full explanations and an example carried through. Despite a brief reference to the gyroscope, this exposition treats the projectile as a particle without drift, and unaffected by questions of stability. The short arcs are handled separately, and the errors introduced by simplifying assumptions as, for example, of the Siacci-type are examined. Five-figure logarithms are used. However, the tables needed for air density and retardation coefficient are not exhibited here.

Two "adjustment coefficients" are used, the first is a form factor for the projectile, the second selects a retardation coefficient from a fixed one-parameter family of such functions. No further freedom in the determination of air resistance is provided for. Happily, modern American ballistic practice is free from computational restraints (of the sort here treated) and from one-parameter retardation laws, and has long implemented its recognition of stability coefficients, especially in air-to-air fire.

A. A. Bennett, USA

Soil Mechanics, Seepage

(See also Revs. 1661, 1808, 1875)

1864. **Ladanji, B., Classification and identification of soils; Nonveiller, E., Shearing strength of coarse-grained cohesionless materials; Šuklje, L., Bearing capacity of cohesive layers of limited thickness and a low degree of perviousness** (in French); **Meischeider, H., The bearing capacity of spread foundations on sandy soils and the security factor of spread foundations; Sovinć, I., Diagrams for the approximate design of circular footings resting on elastic ground; Meischeider, H., and Pandurović, P., Study of earth compaction by Franki pile drivings** (in French); **Lazarević, D., and Kujundžić, B., Mechanical characteristics of mountain masses; Nonveiller, E., The determination of the deformation of loaded rock in tunnels; Janežić, S., Plugging of the "ponors" in the reservoir of the hydroelectric station "Slap Zete,"** *Proc. Yugoslav Soc. Soil Mech. Foundation Engng.*, 52 pp., 1954.

The proceedings, which will be issued at irregular intervals to acquaint foreign readers with soil-mechanics work in Yugoslavia, open with two short accounts on index properties and shearing strength. In a paper on bearing capacity of cohesive layers of limited thickness, L. Šuklje proposes approximate analyses embodying circular slip surfaces for bearing capacity of flexible strip footings with various loads on surface and at shallow depth. Author compares results with Meyerhof's more rigorous method based on plastic theory [AMR **6**, Rev. 3590] and finds good agreement, which is further supported by author's model tests with footings on clay.

After brief theoretical treatments of bearing capacity and settlement of footings, field measurements are described of which, in reviewer's opinion, the most significant are those dealing with the mechanical properties and deformation of rock masses by Lazarević and Kujundžić, and Nonveiller, respectively. Observations of radial deformations in tunnels under uniform radial pressure and measurements in trenches indicate that rock masses are anisotropic so that bending stresses are induced in tunnel linings under uniform loading. Rock masses can be regarded as elastic under usual hydrostatic pressures so that laws of superposition can be applied.

G. G. Meyerhof, Canada

1865. **Lorenz, H., Neumeuer, H., and Lichtl, R., Computation of earth pressure due to line load** (in German), *Bautechnik* **31**, 10, 312–315, Oct. 1954.

Accurate estimation of lateral pressures on retaining walls is very desirable in design, to avoid overstressing or overdimensioning. Paper uses Culmann E-line method and Fröhlich's modification of Boussinesq theory to interpret lateral pressures measured by Gerber on model retaining wall backfilled with medium sand.

Authors conclude Boussinesq theory overestimates wall pressures for sand, and advocate using Fröhlich's concentration factor $\nu = 4$ ($\nu = 3$ gives Boussinesq values). Culmann method gives much higher pressures than Boussinesq theory. For strongly cohesive soils, authors accept Boussinesq values.

Reviewer notes seeming discrepancies in Figs. 3 and 5 of paper. Stresses plotted in Fig. 3 appear to be only half the Boussinesq-Fröhlich values instead of double them (because of wall rigidity) as in Figs. 4 and 5. From Fig. 5 it would appear that line loads of 1.0, 1.8, and 2.5 ton/meter had been actually used, although Gerber in fact only used 1.0 ton/meter [Terzaghi, AMR **7**, Rev. 2153].

Reviewer feels authors' conclusions are largely vitiated by Gerber's tests, having been made with strip loads of length not more than 0.8 × wall height, giving rather lower pressures than truly infinite line loading, and with one intensity only of loading.

T. K. Chaplin, England

1866. **Parsons, J. D., and Wilson, S. D., Safe loads on dog-leg piles,** *Proc. Amer. Soc. civ. Engrs.* **80**, Separ. no. 475, 28 pp., Aug. 1954.

1867. **Ferrandon, J., The mechanics of permeable soils** (in French), *Houille blanche* **9**, 4, 466–480, July/Aug. 1954.

This article, which is a résumé of the first of a series of lectures to students, discusses the laminar flow of water through soils. Emphasis is given to the mathematical development which is elegantly presented.

R. E. Gibson, England

1868. **Bjerrum, L., The conception of homogeneity,** *Schweiz. Arch.* **20**, 7, 221–223, July 1954.

An attempt is made to provide a basis for the estimation of the homogeneity of soils from the result of laboratory tests, and the representativity of such test results is discussed. New quantities are suggested and defined, and their determination from the test result is indicated. Finally, the application is illustrated by an example.

From author's summary

1869. **Kovácsházy, F., Elasticity of rocks** (in Hungarian), *Mélyépitéstudományi Szemle* **3**, 4, 5; 205–212, 248–256, 26 figs., 5 tabs., 1953.

The economical design of structures totally encircled by rock necessitates the exact measurement of the physical and strength properties of the encircling rock. The results obtained are greatly influenced by the method of sampling. The physical and strength properties affecting the design of the structure are dealt with, as well as their methods of determination and measurement. In some cases the anticipated magnitude of stresses in the rock soil should be taken into consideration since the behavior of the rock differs according to the effect of the stress. Special attention should be devoted to the measurement of Young's modulus in the laboratory as well as on the site. Measurings on the site are effected by test loadings and by geophysical methods. The accuracy of the results obtained by the different methods is compared and the conditions of their applicability are established.

Courtesy of Hungarian Technical Abstracts Z. Sz.

1870. **Nascimento, U., Some mechanical problems of soils under the pavement of highways** (in Portuguese), *Minist. Obras Publ. Lab. Engen. Civil. Pub.* no. 32, 23 pp., 1953.

1871. **Higgins, R. V., Study of undersaturation during repressuring and supersaturation during flow of oil to wells,** *J. Petrol. Technol.* **6**, 9, 127–133, Sept. 1954.

Paper concerns the magnitude of the amount of supersaturation that occurs in an underground reservoir during the flow of oil and gas to wells and to the amount of undersaturation that occurs during repressuring of an oil reservoir where some effective permeability to gas exists.

The study is based on earlier laboratory findings of other inves-

tigators on the rate of diffusion of gas in oil as a function of the depth of oil. Utilizing these relationships and the principles of reservoir mechanics, a quantitative estimate of undersaturation and supersaturation was calculated. The results showed that the diffusion of the gas is rapid enough so that, for all practical purposes, no supersaturation exists during the flow of oil to wells or undersaturation during repressuring in reservoir sands having some effective permeability to gas.

The reason diffusion of the gas virtually keeps the oil saturated is the long time required in radial flow for oil to reach the well and the slow rate at which pressure in reservoirs is increased during repressuring. From author's summary

1872. Khein, A. L., Continuous flow of liquids and gases to incomplete wells (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **96,** 1, 33–36, May 1954.

1873. Avery, S. B., Jr., Analysis of ground-water lowering adjacent to open water, *Trans. Amer. Soc. civ. Engrs.* **118,** 178–208, 1953.

Forchheimers' fundamental solution [*Z. Öst. Ing. Arch.* **50,** p. 632, 1898] of steady flow to wells supplied by a line source is used to compute the rate of pumping and drawdown required for dewatering a site adjacent to a river. The actual well installation is replaced by a ring of wells. The idea of representing the installation of wells as a ring, first used by Sichardt in 1928 ["Das Fassungsvermögen von Rohrbrunnen," Berlin, Springer, pp. 43–66] for wells supplied by a circular source, enables the author to integrate the established differential equation. Formulas are given also for two concentric and nonconcentric rings.

The theory of Forchheimer neglects the well loss, and therefore the computed drawdown in vicinity of well may deviate from the actual one. Further in the actual installation measured by the author, there are not the wells reaching through the whole pervious stratum as well as the vertical boundary between the river and soil, as is required by the theory. These and other objections, raised in discussion following the article, and the uncertainty in evaluating the coefficient of permeability, show that the error of formulas can be appreciable.

Z. J. Bažant, Jr., Czechoslovakia

Micromeritics

1874. Hemeon, W. C. L., and Haines, G. F., Jr., The magnitude of errors in stack dust sampling, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-73, 33 pp.

In many industrial and research plants it is important to know the weight, size distribution, and composition of dust suspended in the gases flowing in the system. Authors describe dust sampling methods using exterior and integral filter techniques. They conclude that exterior filter method is prone to serious errors due to deposition in tube leading from sampling nozzle to filter. Errors can be reduced by careful removal of deposits at end of each test. For integral sampling, alundum thimble filters are recommended with glass wool liner to enable coarser thimble to be employed, minimizing pressure drop. Use of the "null" nozzle to obtain isokinetic sampling is discussed; sampling errors are magnified by small departures from the null point. Experiments are described in which dust was sampled at nozzle velocities above and below isokinetic. Excessive nozzle velocities are shown to give lower sampling errors than deficient velocities. These results emphasize the importance of impaction, especially with larger particles (experiments with 80–100 400–500μ silicon carbide). Authors suggest that gas volume samples be expressed as product of area of nozzle and approach stream velocity, irrespective of sampling velocity.

Reviewer feels that authors are to be commended for the caution with which they present their conclusions. It would be a mistake to read into this paper a suggestion that isokinetic sampling was unnecessary. However, where isokinetic sampling is not possible and the dust is coarse, errors can be greatly reduced by use of duct velocity rather than nozzle velocity. For fine dust, such as fly ash, nozzle velocities must still be employed, particularly if dust sample collected is to be studied for size distribution and composition. D. B. Leason, England

1875. Haines, G. F., Jr., and Hemeon, W. C. L., A new method for stack dust sampling, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-74, 22 pp.

This paper follows logically from the authors' previous paper (see preceding review) and describes experiments to test the hypothesis that, when sampling for dust in a duct, the gas volume sampled be expressed as the product of nozzle area and approach stream velocity. Laboratory experiments with fixed or rotary manifold sampler proved effective provided a representative section of the duct was sampled. Using pulverized fuel fly ash, tests were made in a boiler breeching under adverse conditions and were not immediately encouraging due to stratification of the dust and its fine nature. Increased sampling rate giving approximately isokinetic sampling in region of high dust concentration gave satisfactory results. The use of a baffle or dam to reduce stratification is recommended.

D. B. Leason, England

1876. Sandford, F., and Fransson, S., On the separation of roughly disintegrated quartz (in Swedish), *Trans. Chalmers Univ. Technol.* **122,** 24 pp., 1953.

1877. Kobliska, J. J., and Rodenberger, H. J., Mechanical wet sieve testing method, *Amer. Soc. Test. Mat. Bull.* no. 200, 46–47, Sept. 1954.

Fineness tests on finely ground materials frequently give results which vary with the method used. A machine has been devised which standardizes conditions and will make test data comparable between analysts and laboratories.

From authors' summary

Geophysics, Meteorology, Oceanography

(See also Revs. 1593, 1760, 1794, 1824, 1890)

1878. Stern, M. E., Theory of the mean atmospheric perturbations produced by differential surface heating, *J. Meteor.* **11,** 6, 495–502, Dec. 1954.

A mathematical model is used to describe the effects produced in a steady-state atmosphere for a flat rotating earth in which heat is added at the base as the result of air passage over an island or a coast line. The problem is that of predicting the resulting vertical and horizontal displacements of the air stream. An equation for these displacements is obtained from the equations of motion, continuity, and state by the Fourier expansion of a heating function which is proportional to the rate at which nonadiabatic heat is being supplied at a given point. The specific form of this heating function is derived from the first law of thermodynamics and the eddy conduction equation in terms of an arbitrary temperature distribution along the ground, assuming that mean vertical velocities are zero. The general solution of the problem is shown to be equal to the difference between two parts, one in which the displacements satisfy the heat conduction equation and the other in which the displacements are mathematically similar to those resulting from air flow over a mountain. This "equivalent mountain function" thus gives a physi

cal insight into the dynamical effects produced by the heating. The theory is applied to the study of an idealized sea breeze circulation in which the land temperature distribution is taken as a step function and the resulting circulation is shown to give realistic interpretations of well-defined sea breezes. Author concludes that while such an analysis is helpful in small scale differential heating problems, the lack of sufficient information concerning the eddy coefficient type "constants" will limit its effectiveness in studying less familiar meteorological problems. A final section points out the important concept that certain qualitative conclusions regarding heat transfer can be made without requiring the details of the turbulent transfer process.

Reviewer believes that the paper makes an important contribution to atmospheric heat-transfer literature.

J. R. Gerhardt, USA

1879. **Kuo, H.-L., Symmetrical disturbances in a thin layer of fluid subject to a horizontal temperature gradient and rotation,** *J. Meteor.* **11,** 5, 399–411, Oct. 1954.

Fluids heated from below transfer heat by their own motion (convection) as well as by ordinary conduction, provided a nondimensional parameter, the Rayleigh number, exceeds a critical value. Dr. Kuo has extended the classical work of Rayleigh and others on the critical condition for the development of convection and the resulting flow pattern to the case when (a) the fluid, contained between concentric cylinders, is rotating, and (b) one cylinder is maintained at a higher temperature than the other. Equations are linearized and boundary conditions modified in the manner originally adopted by Rayleigh. Agreement with experiment is as good as is to be expected with such approximations.

Problem is important in meteorology and other branches of geo- and astrophysics. It may have engineering applications. Paper is the best attack on the problem reviewer has come across. Clarity and accuracy are up to Dr. Kuo's usual very high standard.

E. T. Eady, England

1880. **Pinney, E., Surface motion due to a point source in a semi-infinite elastic medium,** *Bull. seism. Soc. Amer.* **44,** 4, 571–590, 6 tables, Oct. 1954.

Motion of the surface of semi-infinite elastic body caused by an internal point source is calculated. Source is assumed to be a simple dilatational or rotational one. The axis of rotation is either perpendicular or parallel to the free surface.

Using a special expression for the source, author succeeds in getting a Fourier transform (with respect to time) of the source function in the form sin $(\omega R/c)/\omega R$, which is convenient to express a simple point source. (ω is frequency; R is hypocentral distance; c is S-wave velocity.) This is a new and remarkable way of treatment. [Cf. Y. Satô, AMR **4,** Rev. 3126 and AMR **6,** Rev. 1509.] Process of the integration is shown in the same author's paper [*J. Math. Phys.* **30,** 1–10, 1951]. After getting a final expression for the displacement upon the free surface, numerical calculations are performed for the case $\lambda = \mu$, and the results are presented both in tabular form and graphically. Author suggests that the present way of calculation is not good for the point of large epicentral distance. It is regrettable that the motion near the time of impulse is not calculated.

Y. Satô, Japan

1881. **Kohlsche, K., On the Austausch problem with regard to vertical eddy transfer** (in German), *Z. Meteor.* **8,** 9, 257–275, Sept. 1954.

After some tedious theoretical treatment on the vertical transfer of heat or momentum by turbulence, author attempts to give a unified view of the Austausch problem, which was treated by W. Köppen (1927), W. Schmidt (1925), L. F. Richardson (1920), and many others.

H. Arakawa, Japan

1882. **Van Mieghem, J., Transport and production of vorticity in the atmosphere,** *Tellus* **6,** 2, 170–176, May 1954.

The author studies the equation of d'Alembert and Euler for the rate of change of the vorticity of a continuous medium and the equation of the reviewer [*Phys. Rev.* **73,** 510–512, 1948] for the rate of change of total vorticity. He discusses also the flux of vorticity through a surface. He introduces a rotating coordinate system so as to apply his results to the motion of the earth's atmosphere, and his attention is directed toward meteorological interpretations. He interprets the rates of change of various quantities in terms of atmospheric conditions. Special attention is given to the vertical component of absolute vorticity and to its ratio of change along a meridian.

C. Truesdell, USA

1883. **McDonald, J. E., The shape and aerodynamics of large raindrops,** *J. Meteor.* **11,** 6, 478–494, Dec. 1954.

The physical factors which might be expected to control the shape of large raindrops are surface tension, hydrostatic pressures, external aerodynamic pressure, electrostatic charge, and internal circulation. Each of these is examined quantitatively, and it is concluded that under most conditions only the first three play important roles in producing the deformation characteristic of large raindrops. By analysis of high-speed photographs of water drops falling at terminal velocity, the distribution of aerodynamic pressures is deduced and is shown to imply that separation in the air flow about a raindrop has very significant effects on drop shape. The surface integral of the vertical components of the deduced aerodynamic pressures is found to be in reasonable agreement with the drop weight. The effect of boundary-layer separation on a number of physical processes occurring at the surface of falling drops is noted briefly.

From author's summary

Marine Engineering Problems

1884. **Gertler, M., A reanalysis of the original test data for the Taylor standard series,** *David W. Taylor Mod. Basin Rep.* 806, xi + 45 pp., 7 appendixes (250 pp.), Mar. 1954; Superintendent of Documents, U. S. Govt. Ptg. Office, Washington, D. C. $3.50.

Taylor's original test data have been corrected for restricted channel and transitional flow. Instead of model frictional resistance from old U.S. Experimental Model Basin 20-ft plank experiments, now residual-resistance data have been obtained after Schoenherr frictional deductions for actual water temperature. As this was not measured in original tests, author has recorded its later variation (1913–1918) and believes he has estimated its values in the separate earlier tests within ±1 F.

The results are presented as curves on sheets, each relating to one beam-draft ratio (2.25, 3.00, or 3.75) and one longitudinal prismatic coefficient (C_p). The curves give residual resistance coefficients (C_r) vs. speed-length ratios and, alternatively, Froude numbers for equal volumetric coefficients (substituted for Taylor's displacement-length ratios). The final curves have been adjusted by cross-fairing. Author accentuates several advantages of this kind of representation compared with that of Taylor; e.g., more safe interpolation, to which also the introduction of one more beam-draft ratio contributes. However, these advantages have been reached by loss of surveyable estimation of optimum C_p. For this purpose, curves of C_r vs. C_p for equal volumetric coefficients should be produced as in Fig. 16.

One chapter gives "History of the Taylor standard series" and the following sections give a detailed description of parent and derived model forms.

With its corrections and introduction of modern fundamentals the book is of great value. Criticism may, however, be raised against calculating frictional resistance on the real wetted surface in contradiction to the conclusions of the International Conferences of Ship Tank Superintendents which adopt the product of length and mean girth without any correction of obliquity (though this in the actual case is small). In table 6 and in the illustrative example several errors or misprints are found.

E. Hogner, Sweden

1885. Edstrand, H., Freimanis, E., and Lindgren, H., Experiments with tanker models. II, *Medd. SkeppsProvAnst. Göteborg* no. 26, 20 pp., 1953.

An earlier report entitled "Experiments with tanker models. I," contained results of experiments with models of a single-screw tanker with a displacement of 22,000 tons and a designed speed of about 15 knots. These results indicated that moderately U-form forebody sections were most suitable from the point of view of propulsion.

The present report describes further tests in this series. The influence of length on the propulsive qualities was investigated by testing four different forms, all having the same displacement (22,000 tons) and with a systematic variation in the length to beam ratio from 7.20 to 8.10. The parent form was a model with modified U-form sections. One model was used for investigating the effect of variations in the length of the propeller aperture on the propulsive qualities.

The resistance and self-propulsion test results indicate that, within the limits investigated, variation of length-to-beam ratio has only a slight effect on the resistance and propulsion characteristics. The shortest model ($L/B = 7.20$) gave the worst results in general and only at the lowest speeds did it equal the others in performance. The $L/B = 7.80$ form showed slight superiority over the others.

W. C. Hugli, USA

1886. Edstrand, H., Freimanis, E., and Lindgren, H., Experiments with tanker models. III, *Medd. SkeppsProvAnst. Göteborg* no. 29, 34 pp., 1954.

Two previous reports—"Experiments with tanker models. I and II"—presented some test results of models of a single-screw tanker of 22,000-ton displacement and a designed speed of about 15 knots. In the first report the results indicated that a forebody with moderately U-form sections was most suitable from the point of view of propulsion. In the second report, the results indicated that with such forebody sections, the best propulsive qualities were obtained with a length-to-beam ratio of 7.80 (see preceding review).

The present report describes a continuation of these investigations. Experiments were designed to yield information on the effect of variations in the beam-draft ratio and the block coefficient on the resistance and propulsive qualities. Two beam-draft ratios and four block coefficients were investigated.

The earlier tests were for a vessel of 22,000-ton displacement where variation of block coefficient was not considered important. For larger tankers of about 40,000 tons, block coefficient variations are of greater interest and the tests concerned single-screw tankers of this order of displacement. The draft of the parent form had to be reduced at this greater displacement in order to navigate existing harbors. The reduction in draft also necessitated a reduction in the propeller diameter. The new propeller was designed to absorb approximately the same power as the original one at the same speed and revolution.

W. C. Hugli, USA

1887. Hogner, E., A complementary method for evaluating ship wave resistance, *European Shipbldg.* **4,** 3, 100–103, 1954.

Author published in 1932 [*Jahr. Schiffbautechn. Ges.* **33,** 452–465, 1932] his now well-known and much discussed "interpolation formula." Because of the arduous nature of the calculations, at the time only a very limited number of actual calculations were carried out and compared with results obtained by other wave-resistance formulas. In the present paper the author presents, however, a systematic method for evaluating the interpolation formula, the method being applicable even when the ship lines are given graphically and not mathematically. Results are compared with those obtained by other authors.

J. K. Lunde, Norway

1888. Anonymous, Buckling strength of stiffened panels with applications on the longitudinal strength of ships; numerical applications, *European Shipbldg.* **3, 1,** 5–8, 1954.

1889. Krug, H., Experiences with marine diesel motors [Erfahrungen mit Schiffsdieselmotoren], Berlin, Springer-Verlag, 1954, v + 184 pp., 229 figs. DM 30.

Biomechanics

1890. Grant, W. L., The design and development of a climatic chamber for the study of human reactions under different environmental conditions, *J. S. African Instn. mech. Engrs.* **4,** 5, 133–206, Dec. 1954.

A monumental work in which a climatic chamber is described, in the horizontal- and vertical-flow test chambers of which the environment can be controlled to give any combination of values of the four variables involved between the following limits: (a) Air temperature: from 40 F to 130 F. (b) Air velocity: from 20 to 1000 fpm, in both the horizontal- and vertical-flow test chambers. (c) Mean radiant temperature: The mean radiant temperature of each of the six enclosing surfaces of both the horizontal- and vertical-flow test chambers to be independently varied from 30 F below to 30 F above air temperature, except that the lowest surface temperature required is 35 F.

To satisfy the requirements, the climatic chamber is built in the form of a return flow wind tunnel with two working sections forming the test chambers, one for horizontal flow and the other for vertical upward flow. In each of the two test chambers the walls normal to the direction of air flow are built in the form of bar-grid panels so as to allow the air to flow through them, yet at the same time enabling the mean radiant temperatures to be controlled to within the specified limits.

The bar grids are constructed from plastic bars 6 in. deep, 1 in. wide, and spaced 1 in. apart, with a specially formed tube carrying the temperature-controlling fluid fitted to the 1-in. wide face of the bar which faces the inside of the test chamber. This construction gives an even velocity distribution with a turbulence not exceeding 5.5% in the center of the test chambers for any velocity within the specified limits.

The method adopted for introducing a fixed quantity of fresh air against a varying back pressure but employing a centrifugal fan, the design of the valve systems to give a hot and cold fluid flow range of over 10,000 to 1, and the development of a wet and dry bulb humidity meter for the accurate measurement of high humidity, are also described.

A. Whillier, South Africa